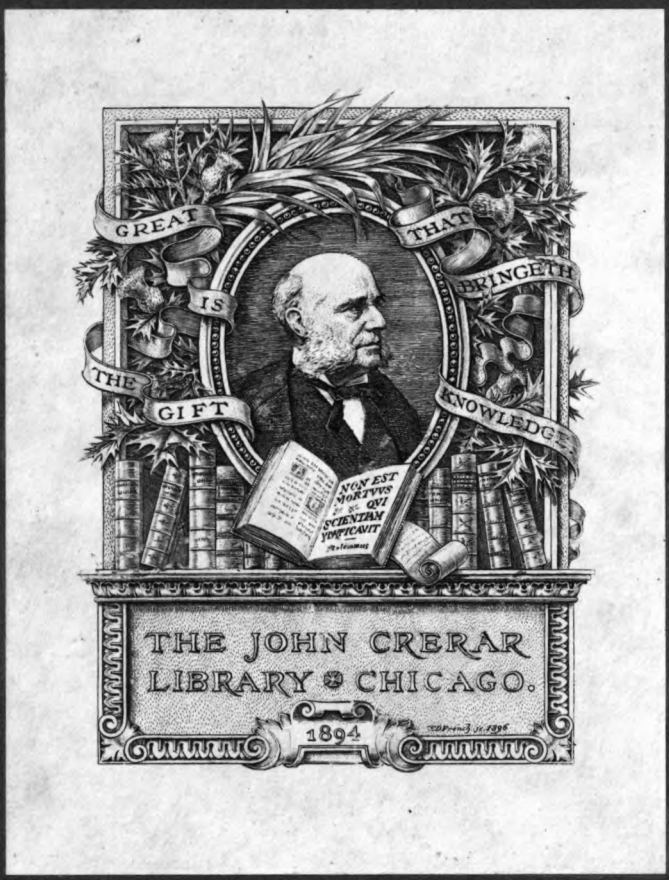
This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

Google™ books

https://books.google.com

The John Crerar Library
Digitized by Google


GREAT IS THE GIFT THAT BRINGETH KNOWLEDGE
NON EST MORTUUS QUI SCIENTIAM VERIFICAVIT
THE JOHN CRERAR LIBRARY CHICAGO.
1894

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

OFFICIAL COPY.

[All Rights Reserved.]

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF

THE COUNTRY AROUND

OTTERBURN AND ELSDON

(EXPLANATION OF QUARTER-SHEET 103 S.E).
(NEW SERIES SHEET 8).

BY

HUGH MILLER, F.R.S.E., F.G.S., Assoc. R.S.M.
(With Notes by C. T. CLOUGH, M.A., F.G.S).

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE,
BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

And to be purchased, either directly or through any Bookseller, from
EYRE AND SPOTTISWOODE, East Harding Street, Fleet Street, E.C.;
ADAM AND CHARLES BLACK, 6, North Bridge, Edinburgh; or
HODGES, FIGGIS, & Co., 104, Grafton Street, Dublin.

1887.

Price Two Shillings and Sixpence.

Digitized by Google

HORIZONTAL SECTIONS,
1 to 139, England, price 5*s.* each.

VERTICA
1 to 75, Engla

COMPLETED COUNTIES OF ENGLAND AND WALES, on a

Sheets marked * have Descriptive Memoirs. Sheets or Counties marked † are il

GLESEY†,—77 N, 78. Hor. Sect. 40.
DFORDSHIRE,—46 NW, NE, SW†, SE†, 52 NW, NE, SW, SE.
RKSHIRE,—7*, 8†, 12*, 13*, 34*, 45 SW*. Hor. Sect. 59, 71, 72, 80.
ECKNOCKSHIRE†,—36, 41, 42, 56 NW, SW, 57 NE, SE. Hor. Sect. 4, 5, 6, 11, a
CKINGHAMSHIRE,—7* 13* 45* NE, SE. 46 NW, SW†, 52 SW. Hor. Sect. 74, 79.
ERMARTHENSHIRE†,37, 38, 40, 41, 42 NW, SW, 56 SW, 57 SW, SE. Hor. Sect. 2–4
ERNARVONSHIRE,†—74 NW, 75, 76, 77 N, 78, 79 NW, SW. Hor. Sect. 28, 31, 40.
RDIGANSHIRE†,—40, 41, 56 NW, 57, 58, 59 SE, 60 SW. Hor. Sect. 4, 5, 6.
ESHIRE,—73 NE, NW, 79 NE, SE, 80, 81 NW*, SW*, 88 SW. Hor. Sect. 18, 43, 4
RNWALL†,—24†, 25†, 26†, 29†, 30†, 31†, 32†, & 33†.
NBIGH†,—73 NW, 74, 75 NE, 78 NE, SE, 79 NW, SW, SE, 80 SW. Hor. Sect. 31, 35, 38,
RBYSHIRE†,—62 NE, 63 NW, 71 NW, SW, SE, 72 NE, SE, 81, 82, 88 SW, SE. Hor.
VONSHIRE†,—20†, 21†, 22†, 23†, 24†, 25†, 26†, & 27†. Hor. Sect. 19.
RSETSHIRE,—15, 16, 17, 18, 21, 22. Hor. Sect. 19, 20, 21, 22, 56. Vert. Sect. 22.
SEX,—1*, 2*, 47*, 48. Hor. Sect. 84, 120.
INTSHIRE†,—74 NE, 79. Hor. Sect. 43.
AMORGANSHIRE†,—20, 36, 37, 41, & 42 SE, SW. Hor. Sect. 7, 8, 9, 10, 11; Vert. Se
OUCESTERSHIRE,—19, 34*, 35, 43 NE, SW, SE, 44*. Hor. Sect. 12 to 15, 59; Vert.
MPSHIRE,—8†, 9†, 10*, 11†, 12*, 14, 15, 16. Hor. Sect. 80.
REFORDSHIRE,—42 NE, SE, 43, 55, 56 NE, SE. Hor. Sect. 5, 13, 27, 30, 34; and
RTFORDSHIRE,—1† NW, 7*, 46, 47*. Hor. Sect. 79, 120, 121.
NTINGDON,—51 NW, 52 NW, NE, SW, 64*, 65.
NT†,—1† SW & SE, 2†, 3†, 4*, 6†. Hor. Sect. 77 and 78.
NCASHIRE,—79 NE, 80 NW*, NE, 81 NW, 88 NW, SW†, 89, 90, 91, 92 SW, 98. Hor. S
27, 34, 61.
ICESTERSHIRE,—53 NE, 62 NE, 63*, 64*, 70*, 71 SE, SW. Hor. Sect. 46, 48, 49, 52, 12
ERIONETHSHIRE†,—59 NE, SE, 60 NW, 74, 75 NE, SE. Hor. Sect. 26, 28, 29, 31, 3
DDLESEX†,—1† NW, SW, 7*, 8†. Hor. Sect. 79.
ONMOUTHSHIRE,—35, 36, 42 SE, NE, 43 SW. Hor. Sect. 5 and 12; and Vert. Se
ONTGOMERYSHIRE†,—56 NW, 59 NE, SE, 60, 74 SW, SE. Hor. Sect. 26, 27, 29, 3
ORTHAMPTONSHIRE,—64, 45 NW, NE, 46 NW, 52 NW, NE, SW, 53 NE, SW, &
OTTINGHAM,—70*, 71* NE, SE, NW, 82 NE*, SE*, SW, 83, 86, 87* SW. Hor. Sect. 60
XFORDSHIRE,—7*, 13*, 34*, 44*, 45*, 53 SE*, SW. Hor. Sect. 71, 72, 81, 82.
EMBROKESHIRE†,—38, 39, 40, 41, 58. Hor. Sect. 1 and 2; and Vert. Sect. 12 and 13.
ADNORSHIRE,—42 NW, NE, 56, 60 SW, SE. Hor. Sect. 5, 6, 27.
UTLANDSHIRE†,—this county is wholly included within Sheet 64.*
HROPSHIRE,—55 NW, NE, 56 NE, 60 NE, SE, 61, 62 NW, 73, 74 NE, SE. Hor.
45, 53, 54, 58; and Vert. Sect. 23, 24.
OMERSETSHIRE,—18, 19, 20, 21, 27, 35. Hor. Sect. 15, 16, 17, 20, 21, 22; and Vert.
TAFFORDSHIRE,—54 NW, 55 NE, 61 NE, SE, 62, 63 NW, 71 SW, 72, 73 NE, SI
24, 25, 41, 42, 45, 49, 54, 57, 51, 60: and Vert. Sect. 16, 17, 18, 19, 20, 21, 23, 26.
UFFOLK,—47,* 48,* 49, 50, 51, 66 SE*, 67.
URREY,—1 SW†, 6†, 7*, 8†, 12†. Hor. Sect. 74, 75, 76, and 79.
USSEX,—4*, 5†, 6†, 8†, 9†, 11†. Hor. Sect. 73, 75, 76, 77, 78.
ARWICKSHIRE,—44*, 45 NW, 53*, 54, 62 NE, SW, SE, 63 NW, SW, SE. Hor. Se
ILTSHIRE,—12*, 13*, 14, 15, 18, 19, 34*, and 35. Hor. Sect. 15 and 59.
ORCESTERSHIRE,—43 NE, 44*, 54, 55, 62 SW, SE, 61 SE. Hor. Sect. 13, 23, 25, 5

GENERAL MEMOIRS OF THE GEOLOGICAL

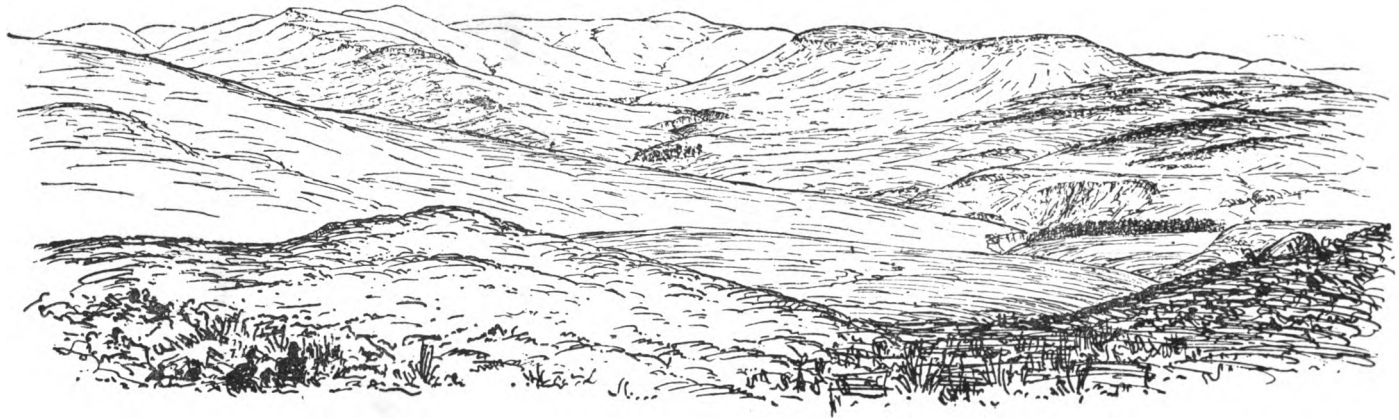
EPORT on CORNWALL, DEVON, and WEST SOMERSET. By Sir H. T. De La B
IGURES and DESCRIPTIONS of the PALÆOZOIC FOSSILS in the above Cou
he MEMOIRS of the GEOLOGICAL SURVEY of GREAT BRITAIN. Vol. I., 21*s.*;
ORTH WALES. By Sir A. C. Ramsay. Appendix, by J. W. Salter and R. Eth
of Memoirs, &c.)
The LONDON BASIN. Part I. Chalk and Eocene Beds of S. and W. Tracts. By
Memoirs, &c.)
Guide to the GEOLOGY of LONDON and the NEIGHBOURHOOD. By W. Whit

Digitized by Google

Digitized by Google

Frontispiece.

View into Cottonshope Burn, across Redesdale from the south (Fell Sandstones and Cement-stones).



Digitized by Google

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF

THE COUNTRY AROUND

OTTERBURN AND ELSDON

(EXPLANATION OF QUARTER-SHEET 108 S.E).
(NEW SERIES SHEET 8).

BY

HUGH MILLER, F.R.S.E., F.G.S., Assoc. R.S.M.
(With Notes by C. T. CLOUGH, M.A., F.G.S).

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE,
BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

And to be purchased, either directly or through any Bookseller, from
EYRE AND SPOTTISWOODE, East Harding Street, Fleet Street, E.C.;
ADAM AND CHARLES BLACK, 6, North Bridge, Edinburgh; or
HODGES, FIGGIS, & Co., 104, Grafton Street, Dublin.

1887.

Price Two Shillings and Sixpence.

Digitized by Google

Digitized by Google

NOTICE.

The area included within this Map was surveyed by Mr. Hugh Miller, with the exception of its north-western part, and also a strip (about one mile wide) along the northern edge. These are the areas included in Sheet 41 (6-inch Northumberland) and the southern parts of Sheets 34, 35, and 36; they were surveyed by Mr. C. T. Clough, who has supplied the descriptive notes relating to them.

The Silurian and Old Red Sandstone rocks with their associated igneous rocks are entirely within Mr. Clough's area.

The whole was surveyed under the superintendence of Mr. H. H. Howell.

This being the first Memoir of the Geological Survey devoted to the Carboniferous Rocks of the English Border, a fuller description of their general characters is given than in most Sheet Explanations. The interesting phenomena connected with the glaciation of the district are also discussed in some detail.

The lower Carboniferous beds (Tuedian), which were hitherto considered to be almost unfossiliferous, have yielded a considerable number of fossils to the Survey Collectors—Messrs. A. Maconochie and J. Rhodes. Mr. R. Kidston has named the plants in the lists of these and other beds; Mr. B. N. Peach has determined the Crustacea, identifying some of the forms as new species, which will be described elsewhere; Mr. J. W. Kirkby has assisted in naming the Ostracoda; all the other fossils having been named by Messrs. G. Sharman and E. T. Newton.

H. W. Bristow,
Senior Director.

Geological Survey Office,
28, Jermyn Street, S.W.,
29th July 1887.

U 18862. Wt. 10025.

554.2
O700

513138
245854

Digitized by Google

Digitized by Google

CONTENTS.

Page.

NOTICE.—By the Senior Director - - - - - - v

CHAP. I. INTRODUCTION.—Area. Physical Features. Geological Formations. Their Classification. The General Succession in Redesdale - - - - - - - - - 1

CHAP. II. SILURIAN AND OLD RED SANDSTONE.—Wenlock Beds. Old Red Sandstone - - - - - - - 7

CHAP. III. CARBONIFEROUS LIMESTONE SERIES.—*Lower or Tuedian Group.*—Basement Beds. Conglomerate on the West side of Ramshope. Lower Freestone and Cementstone Beds. In Redesdale. In Coquetdale. Cementstone Group in Whitefield Burn, Swindon Burn, and Dry Sike - - - - - - - - 9
The Fell Sandstones.—In Coquetdale. In Redesdale - - 14

CHAP. IV. CARBONIFEROUS LIMESTONE SERIES, *continued.*—*The Carbonaceous Division.*—In Coquetdale—Swindon Burn, Ovenstone and the Crag, Billsmoor Park, North Yardhope. Redesdale—North Tynedale—*Lower Part; from the bottom of the Carbonaceous Division to the Pipers Cross Limestone.*—Coals under the Plashetts Seam. Plashetts Coal.—*Upper Part; beds overlying the Piper's Cross and Belling Limestone* - - - - - - 20

CHAP. V. CARBONIFEROUS LIMESTONE SERIES, *continued.*—*Upper Limestone Series or Calcareous Division.*—Hareshawhead District. District of Sundaysight. High Green, with the Padon Hills south of Gib Shield. District of Brownrigg and Ratten Row. District of Bennettsfield, Yatesfield, and Ballyardly Hill. Outliers near the Rooken Cairn. District of Wishaw, Rochester, Ottercops, Raylees, Monkridge, and Todholes. District of Elsdon, Soppit, Landshot, Hudspath, Carrick, and Penchford; together with the faulted area at Rimpside. District of Otterburn, Girsonsfield, Greenchesters, Shittleheugh, and Davy Shield. District of Potts-Durtrees and Dudlees, with parts of Wilkwood and North Yardhope - - 42

CHAP. VI. FAULTS.—I. *Boundary Faults.*—Boundary faults of the Silurians.—Of the lower Carboniferous formation—Dour-hill-end fault, Hepple fault, Swindon fault.—Of the upper Carboniferous formations—Darden fault, Grasslees fault, Yatesfield-Yardhope fault. Faults of the Rooken outliers—Gib Shield fault, Padon Hills fault, Tarret and Hazle Cleugh fault, Sundaysight and Ottercops fault, Hareshaw fault, Highgreen fault, Black Crag and Sundaysight Cleugh faults, Hareshawhead fault, faults of the Elsdon district.—II. *Faults whose known effects are limited to the interior of the formations.*—III. *Faults not actually known* - - 68

CHAP. VII. PALÆONTOLOGY.—Upper Silurian. Lower Tuedian. Fell Sandstones or Upper Tuedian. Carbonaceous Division. Upper Limestone Series - - - - - - - - 81

CHAP. VIII. IGNEOUS ROCKS.—*Contemporaneous.*—Rocks of Old Red Sandstone age. Rocks of Carboniferous age. Cottonshope Basalts - - - - - - - - - 95
Intrusive.—Felstone Dyke (Pre-Carboniferous). Basaltic Dykes (Post-Carboniferous).—Elsdon, Otterburn, and High Green Dykes. Various other Dykes. Intrusive Sheet of Lumsdon Law - - 97

CHAP. IX. GLACIATION OF THE DISTRICT AND GLACIAL PHENOMENA.—Glacial Striæ. Glacier Erosion. Transport of Boulders. Transported Rock Masses. Boulder Clay or Till. Kames, Kame-

Digitized by Google

Page.

like Mounds and Moraines. Kames and Moraines in Whiskershield Burn. Moraine at Ravenscleugh. Kame-gravel at Harbottle. Other Gravel Mounds - - - - - - 102

CHAP. X. POST GLACIAL DEPOSITS.—River-alluvia and terraces. Peat Mosses and Buried Forests - - - - - 111

CHAP. XI. PHYSICAL HISTORY OF THE DISTRICT.—Summary of Physical events. Development of the Configuration. Preglacial courses of streams, or Buried channels. Landslips - - 113

CHAP. XII. ECONOMIC GEOLOGY AND MINERAL RESOURCES.—Building Stones, Millstones, and Road Metal. Limestone. Ironstone. Coal. Lead. Bricks and Tiles. Peat. Springs and Mineral Waters. Agriculture - - - - - - 122

APPENDIX I. LIST OF THE CHIEF PUBLICATIONS ON THE DISTRICT. 128

APPENDIX II. GLOSSARY OF LOCAL TERMS. 130

APPENDIX III. BORINGS AND SINKINGS (not included in the Text). 132

LIST OF ILLUSTRATIONS.

Page.

Frontispiece.—View into Cottonshope Burn, across Redesdale from the south.

Fig. 1.—Section across the Swindon Faults - - - - 15

„ 2.—Section of Carbonaceous Beds at Midgy Holes, the Comb, Tarset Burn - - - - - - - - 21

„ 3.—Section at Elsdon Mill - - - - - 43

„ 4.—View of a part of Ray Crag, Kirkwhelpington Common - 104

„ 5.—Sketch-section of a valley, showing the relative positions of the pre-glacial and post-glacial streams - - - 117

Digitized by Google

THE GEOLOGY OF

THE COUNTRY AROUND

OTTERBURN AND ELSDON.

CHAPTER I.—INTRODUCTION.

AREA.—PHYSICAL FEATURES.—GEOLOGICAL FORMATIONS.

THIS quarter-sheet of the Geological Survey of England represents 216 square miles of the county of Northumberland, on the scale of one inch to the mile. The upland district thus included is traversed from N.W. to S.E.—almost in a diagonal manner—by the pastoral valley of the river Rede, from within a mile of its source on the east side of Carter Fell, to within 4 miles of its junction with North Tynedale. In its south-west corner, near Falstone, it contains a portion of the North Tyne itself, with a large part of one of its main tributaries, the Tarset Burn. In the north-east again it includes the river Coquet from Alwinton Church down to Hepple. These four chief streams of the map,—the Coquet, the Rede, the Tarset, and the North Tyne,—pursue the parallel south-easterly course characteristic of so many Northumbrian rivers.

The general surface of the ground is a gently inclined plateau or plane, sloped in the direction of the flow of the rivers, and sculptured into a variety of confluent hills and dales. At its highest part, *i.e.*, to the right and left of the head waters of the Rede, this tumbled incline rises into moory heights from 1,500 to 1,800 feet above the sea, the chief of which are Oh Me Edge, 1,809 feet, Girdle Fell, 1,739 feet, Hungry Law, 1,642 feet, and Raven's Crag, 2 miles east of Hungry Law, 1,729 feet high. These, with the neighbouring hills, and the hills of the uplands generally, strike the eye upon the whole as curiously equal-topped; it is, in fact, the uniformity of the heights that gives to the district its plateau-like aspect. Towards the south-east the summits steadily decrease, from 1,500 and 1,800 feet, to 1,000 and 1,200 feet.

In their general aspect these billowy uplands are a variegated patchwork of dark heather and "white ground,"—the latter clad in the coarse grasses or "bents" which lie more or less bleached for seven or eight months in the year, and so termed by the shepherds. Hence perhaps such names as White Hill, Whitlees, Whitefield, &c. The prevalence of heather and peat again might be inferred from such names as Black Moor, Black Burn, Black Blakehope, and the like, which occur here and there over the greater part of the map. The Harbottle Hills, west of the Coquet, are perhaps the most savage wilderness of crags, scars, and black moor to be found anywhere in the county, and the whole of the moors ex-

Digitized by Google

tending south-eastward into the Darden Fell and Simonside Hills are of the same general type. The lower half of the Holystone Burn is more like a heathery Highland glen than a vale of the English uplands. In the great belt of high ground stretching *westward* from the Harbottle Hills to Black Kip and Down Hill, and extending (beyond the deep head valleys of the Rede) to Girdle Fell, Oh Me Edge, and Little Monkside, the eye meets little but sheets of hill peat, scars of sandstone, and ranges of moory "edge" or escarpment, the extent and extreme solitude of which leave on the mind a sense of impressive desolation. In strong contrast with this dark belt, and lying along the north-east border of the map, and scarcely at all entering it, are the green and finely grouped and high up-arching hills of the Cheviots. From the top of Crigdon Hill the two types of scenery are seen almost at their best, and placed face to face;—to the north—the smooth, green, and rounded,—to the south, the brown, shaggy, and linear. The south-eastern half of the district (occupied by the Upper Limestone Series), is more varied than the sandstone moors. It is much mingled with *white ground*, and relieved by occasional green strips or "gairs" of limestone-grass. Between Elsdon and the classic Otterburn we find a considerable extent of green and undulating downs, at one time under the plough.

Except in some few tracts which are covered with drift and almost featureless, notably the western slopes of mid-Redesdale, which are bare almost to desolation, escarpments and crags form what might be termed the general surface-sculpture of the ground, especially on the west side of Coquetdale,—on the east side of Redesdale north of Rochester—at the head of Hindhope—and on the west side of the Tarset Burn—and in that fine succession of ascending steps that rises eastward from the Rede into Hartside and Wishaw Pike. The chief valleys, with the exception of the head valleys of the Rede, which are deep and closely bordered by the high fells, are open and pastoral. Passing north-eastward over the fells to the Coquet the character of the country is seen suddenly to change, and looking across that river from the brown verge of the uplands, the eye is cast over a tract of green lowlands gently rising into the Cheviot Hills, laid out in fields and largely arable. In the other valleys the extent of the "arable" is limited to their alluvial flats and lower slopes, especially on the sides facing the sun, on which (very markedly in Redesdale, Tarset, and Tynedale,), the enclosed grounds rise higher and greener. Some fir plantations, chiefly of the clothes-brush form abhorred by the artist, flourish in their vicinity. But Otterburn resembles a choice bit of the woodlands dropped in its pastoral valley, and "sweet Woodburn's cottages and trees" are worthy of their delineation in a single couplet by Scott. The old birchen shaws, the remains of which abound in the peat mosses, still maintain some footing here and there in the marshy hollows and slopes, especially on the west side of Coquetdale and Redesdale; but their seedlings are destroyed

Digitized by Google

by the sheep, and the natural wood, except where enclosed, is dying out.

Tabular View and General Description of the Rocks.

The rocks and superficial deposits of this tract of country fall under the following divisions, which are placed under the two main groups of *Aqueous* and *Igneous*, and arranged, so far as is possible, in chronological order.

Aqueous Rocks.

Recent Deposits :—
- Peat.
  - Hill Peat.
  - Basin Peat.
- Alluvium and lower alluvial terraces.
- River gravels, or upper alluvial terraces.

Glacial Deposits :—
- Glacial gravels, chiefly in the form of kames or eskers : passing into moraines of angular débris.
- Boulder Clay or Till.

Carboniferous Limestone Series :—
- Upper Series.
  - Calcareous Division.
- Lower Series.
  - Carbonaceous Division (Scremerston Beds).
  - Tuedian Division or Tweed Beds.
    - Fell Sandstones.
    - Cementstone Beds and Rothbury Limestones.
    - Lower Freestones.
    - Basement Beds.

Lower Old Red Sandstone :—
- Associated with volcanic rocks.

Upper Silurian Rocks :—
- Wenlock Beds.

Igneous Rocks.

Interbedded or Contemporaneous Igneous Rocks : —
- Basalt, contemporaneous with the Lower Limestone Series.
- Cheviot porphyrite and volcanic ashes, contemporaneous with the Lower Old Red Sandstone.

Intrusive igneous rocks :—
- Felstone dyke, of pre-carboniferous age.
- Basalt, of post-carboniferous age, chiefly in the form of dykes, some of which probably date from the Tertiary period.

In the following chapters these formations are taken up in reverse order, beginning with the oldest. A preliminary view of the Palæozoic rocks is added here.

Wenlock Beds.

Pencil shales, Graptolite-shales, and bands of greywacke or grit ; chiefly greenish-grey in colour ; with high dips and sharp foldings. These beds occur in Redesdale Head, and in the Ramshope and Lumsdon Burns.

Digitized by Google

Lower Old Red Sandstone (Porphyrites).

Purple porphyrites, interstratified with thin beds of ash, or ashy sandstone, and associated in Lumsdon Burn with some Red Sandstone. Preserved in small patches at Redesdale Head, and in Lumsdon Burn and Ramshope. The edge of the main porphyrite mass of the Cheviot Hills appears in Ridlees Burn.

Carboniferous Limestone Series.

Tuedian Division, or Tweed Beds.

a. *Tuedian* (?) *Basement Beds.*—A thick, coarse and very local conglomerate of porphyrite and greywacke on the west side of Ramshope.

b. *Lower Freestones.*—A group of freestones, often coloured red and spotted with brown ochre; associated with reddish and greenish shales; the grits at the base marked by a thin scattering of quartz pebbles and small fragments of underlying rocks, chiefly west of the Silurian boundary-fault. Thickness variable, from 200–350 feet. These beds appear at Redesdale Head near the Silurians; and at Cottonshope Head. In Coquetdale they are not separately distinguished.

c. *Cementstones and Rothbury Limestones.*—Greenish shales, subordinate sandstones chiefly of a composite texture, and limestone bands poor in fossils. These resemble cementstones; in Coquetdale they thicken out into a group of buff and flaggy limestones. Localities; Redesdale, where the group may average 200–300 feet; Coquetdale, where it has increased to not less than 1,000 feet; and a narrow strip passing over between these valleys.

d. *Fell Sandstones.*—Thick quartzose grits with some purple and greenish clays; two or three rare and streaky layers of coal. This group occupies the moors from the west side of the Coquet by Ridlees Cairn over to the Cementstone area of Redesdale, with a considerable tract of the uplands beyond it. From nearly 2,000 feet at the edge of the map in Coquetdale, it thins to about 500 feet in Carter Fell a little to the west of the Map.

Carbonaceous Division (or *Scremerston Beds*).

Sandstones, carbonaceous-grey shales, calcareous grits, and limestones. Carbonaceous matter prevalent throughout. Many thin coals. Limestones increasing towards the S.W., and the whole group thickening from 900 feet in Coquetdale to about 2,500 feet in the north part of the North Tyne Basin. This group extends in an irregular semicircle from Swindon Burn into North Tynedale and Lower Redesdale. Several inliers of the Carbonaceous Division also occur within the area of the overlying group next to be mentioned.

Digitized by Google

Upper Limestone Series; Calcareous Division.

Beds of marine limestone associated with shales, sandstones, and thin coals; a gradation in each case from the limestones up into the coals, in which the shales and sandstones appear as passage-beds between. About 1,100 feet of these strata appear in the Map—the well known ironstone-shale of the Redesdale Limestone marking the base. They occupy an irregular and much faulted area in its south-western part. Two outliers are preserved in the Carbonaceous Group near Rooken Cairn.

The Classification.—The Carboniferous Limestone Series on the south side of the Border owes its classification originally to the late George Tate of Alnwick, who, between 1849 and 1868, worked it out in some of the less disturbed districts of North Northumberland. This classification into *Tuedian, Carbonaceous,* and *Calcareous* groups applies to the entire Northumbrian Type of the Carboniferous Limestone, including Northumberland, East Cumberland, and Eskdale and Liddisdale in Scotland. The name *Tuedian* Tate proposed in 1856,* for the lower part of the series "between the productal and encrinital limestones and the Upper Old Red Sandstone." It is a name not free from objection, belonging to an unwholesome class of terminology; and would be better translated into the vernacular as simply the *Tweed Beds.* The great belt of massive sandstones here described as the *Fell Sandstones,* Tate on one occasion called "Tuedian Grits," but he seems never again to have employed the term. Two years later his continued researches had shown† that the "productal and encrinital limestones" could be divided into two natural groups, a lower *Carbonaceous* group, *i.e.* the Scremerston Coal Series,—and an upper *Calcareous* group, with the Dun Limestone, now known to be the same as the Redesdale Limestone of this Map, at its base. These are the main divisions here adopted.

The subordinate members have been named by the officers of the Geological Survey. The term Fell Sandstones (equivalent to Tate's "Tuedian Grits") was first employed in Scotland in the compound form of *Larriston-Fell* Sandstones, these being the massive sandstones of a part of Larriston Fell between the North Tyne and Liddisdale. Its descriptive force and euphoniousness have extended it to the whole range.‡ The beds under the Fell

* Proc. Berwicksh. Naturalists Club, 1850–56. Vol. III., p. 219.

† Proc. Berwicksh. Club, 1866. Vol. V., p. 283.

‡ Priority might justly be claimed for Tate's name (*Tuedian Grits*), but this term was never used even by Tate himself. Older also are such terms as *Bewcastle Grits, Rothbury Grits, Simonside Grits,* and *Harbottle Grits,* applied to different parts of the range before they were known to be all parts of one series. But on the score of mere priority, they ought all to give way to a term of William Smith and J. Phillips, *Crag Sandstones,* a name unfortunately similar to some others already in general use. But perhaps it sufficiently resembles Fell Sandstones to be translated so, without any suspicion of dishonour to those who first used it.

Digitized by Google

Sandstones have been long familiarly known by the Survey as Cementstones. But it is quite necessary to qualify this term, the Cementstones of Scotland occupying a much higher horizon. Near Rothbury and again in Bewcastle, however, they pass into true limestones, and the group can perhaps best be known as a group of *Cement-limestones*. The local term *Rothbury Limestones* has been employed by the writer; the terms *Lower Freestones* and *Basement Beds* by Mr. Clough.

In descending the long valley of the Rede we traverse these groups of rock almost in the order of their age. In the extreme head of the valley, above Lumsdon, we have sections of the contorted shales and grits of Wenlock age, and of the irregular basement beds of the Carboniferous that unconformably cover them; with glimpses of the patches—unconformable to both—of porphyrite and Old Red Sandstone that have been preserved between. Some of the Lower Freestones with their coloured shales can be seen in the stream west of Whitelee, and at the very head of the valley. The cementstone beds, with their thinner sandstones, greenish shales, and courses of impure limestone occupy the slopes of the valley under the strong copeing of massive Sandstones that borders the dales between Chattlehope and Low Byrness; they can best be seen in the side streams. The Fell Sandstones conspicuously justify their name in the neighbouring heights, such as Byrness Hill and the Raven, Countess, and Ellis Crags. They are excluded from the valley, however, by a powerful fault with southerly down-throw, which obscures even the base of the Carbonaceous group that overlies them. Near the foot of the Bellshield and Sills Burns, it can be seen from the stream sections, and the heaps of black pit-débris, that the sandstones are now intercalated with carbonaceous shales, and coals, and impure limestone bands. Lastly, at the foot of Durtrees Burn, and from there over the shoulder of the hill to Greenchesters, there is an ascending series of beds marked by the presence of zones of marine limestone, each covered in orderly sequence by shale and sandstone. The limestone at Greenchesters appears to be one of the highest beds in the Map.

Digitized by Google

CHAPTER II.--SILURIAN AND LOWER OLD RED SANDSTONE.

Wenlock Beds.

The Silurian rocks of this Map occupy between two and three square miles of ground at the head of Redesdale. They occur in a forked patch rudely shaped like a barbed spear head. Its angular point, at Ramshope, is directed southward, its shaft extends up Ramshope Burn, its western barb goes up Redesdale and reaches a mile beyond Whitlee, and its eastern barb with Carboniferous rocks faulted down on both sides of it, passes the head of Hawk Burn to the Border at Greyhound Law. The southernmost of these faults is the boundary-fault of the Silurian area, and is carried from the Border in a line extending to Ramshope and the foot of Coomsdon Burn. The heights east end west of the Ramshope and Lumsdon Burns are occupied by Carboniferous rocks and the trap of Lumsdon Law, with some patches of the Cheviot porphyrites preserved between the basement of the Carboniferous and the old contorted rocks below.

These old rocks consist of shales, — of a kind at one time used by the school children for slate pencils, and hence called "pencil shales" — and bands of greywacke. The shales are grey or greenish-grey, sometimes weathering to a rusty or ochreous yellow. Certain finely grained and delicately striped-looking varieties contain remains of graptolites, but these fossils are seldom well preserved, and can be detected only after careful search. The greywackes vary in their texture from a fine-grained stone in which the particles are scarcely discernible, to a conglomerate with included fragments as much as eight or ten inches long. The fragments of these conglomerates are apparently derived from contemporaneous shales, and the beds containing them are usually local and lenticular. The Silurian greywackes, which are sometimes calcareous enough to effervesce with dilute hydrochloric acid, are not unlike some of the Carboniferous sandstones of the Border districts, for which in hand specimens or isolated boulders they may easily be mistaken. Such greywacke-like sandstones are probably a re-formation of Silurian materials.

Where the Silurian rocks are overlaid by the reddish Carboniferous strata, their natural grey or greenish colour has been stained to some shade of purple or of hæmatite red. The porous greywackes, which most readily absorbed the colouring matter, are often dyed all through; the shales on the other hand are coloured chiefly along their bedding planes and prominent joints.

The dip of these strata is generally high. Their curves and convolutions are complicated and sharp. In some cases the flexures are so sudden that the soft pencil shales are squeezed out from between the bands of greywacke, for some little distance, with a local appearance of unconformity. Near the surface of the

Digitized by Google

ground the dips must be taken with caution, being liable to be reversed superficially by "the weight of the hill", *i.e.*, the slow downward drag of the surface, acting on the edge of the strata. Cleavage in this district occurs only in the exceptionally fine-grained shales. In alternating greywackes and shales an alternation of cleaved and non-cleaved beds is sometimes to be observed; as, for instance, a few yards up a small sike or streamlet near the large angle of the main feeder (Inner Cleugh) of Ramshope Burn, 130 yards below the foot of Scary Cleugh.

Lower Old Red Sandstone.

Associated with the Cheviot porphyrite, afterwards to be fully described, in Lumsdon Burn, there are two small patches of sandstone of a warm Indian-red colour, rather marly in their texture and with occasional thin grey or yellow bands. It is uncertain whether these are really interbedded with the porphyrites; they are not actually seen between them. They are marked, moreover, by an absence of the porphyrite fragments and broken crystals of felspar which usually abound in similar sandstones where these are interbedded with the porphyrites in other parts of the Cheviots; but on the whole they may safely be relegated to the Old Red Sandstone.*

Besides these there is a bed of red or chocolate-coloured sandy clay and conglomerate, associated with a patch of porphyrite on the further side of Hen Cleugh, about half a mile north-west of Whitelee. It contains abundance of chocolate-stained pebbles of the Silurian rocks, on which the patch directly rests; in one place there also appears to be some boulders of Cheviot porphyrite, one of them nearly two feet in length. The conglomerate is not actually seen to pass under the porphyrites.

* At Hindhope on the Scottish side, as I am informed by my colleague, Mr. B. N. Peach, some sandstones, red, marly and *without* the porphyrite fragments or the broken felspar crystals, are actually seen between masses of Cheviot porphyry.

Digitized by Google

CHAPTER III.—CARBONIFEROUS LIMESTONE SERIES.

Tuedian Division or Tweed Beds.

Basement Beds.

Where the strata of the Carboniferous Series rest upon the older rocks and the country is free from peat and drift, the unconformable junction between them is usually clearly marked by a feature and a line of springs. There is in general no true conglomerate at the base; but for a few feet near the bottom the freestone contains small pebbles of the underlying rock, mingled with quartz pebbles more numerous, better rounded, sometimes one or two inches in length and derived from some source unknown. This is the pebbly base of the Lower Freestones, and is in no respects separable from them.

Tuedian (?) *Conglomerate on the west side of Ramshope.*—On the west side of Ramshope, however, the freestones of the carboniferous have at their base for some distance a thick bed of coarse conglomerate made up of porphyrite and Silurian greywacke. Its position is marked by green ferny slopes, rather hummocky in their outline, and deeply cut by the little streamlets that descend from the base of the freestones. The fragments of porphyrite, which are the largest of the boulders it contains, are generally soft and decomposed. They seem to consist of a medium-grained purple porphyrite not very well rounded. Many of them enclose irregular bands and amygdaloidal cavities of red jasper and banded agate, stained green or deep hæmatite-red upon the outside. These, from their hardness, are conspicuous among the loose stones of the little streams, and are locally known as the Redewater jaspers. When cut and polished they make handsome centres for jewellery. The surface soil is of a deep purple red.

Of the conglomerate now described the best exposures occur a little beyond the edge of this map. At a point a quarter of a mile south of West Edge they have at first sight an ashy aspect; but in the other exposures nearer the head of Ramshope some of the bands consist almost entirely of Silurian pebbles, and seem to be interstratified with the rest of the rock.* If we accept this rather doubtful bed as a basement conglomerate of the Carboniferous, it must be supposed to have the extremely local occurrence characteristic of very coarse beds, thinning rapidly both to the south and east. It is open to discussion, however, whether it should not be classed as Upper Old Red Sandstone.

* It is to be noted that at Thirlmoor, about five miles to the N.E., the true ash where it rests upon the Silurian strata contains scarcely any Silurian fragments, even at its base. The staining of the pebbles in this Ramshope conglomerate strongly reminds one of the conglomerates at Windy Gyle, in Quarter-sheet 108 N.E.

Digitized by Google

There is possibly another and much smaller exposure of the same conglomerate on the Lumsdon side of West Edge.

Lower Freestones and Cement-Limestones.

(*Lower Tuedian.*)

Redesdale.—At the head of Redesdale the Carboniferous strata between the older rocks and the Fell Sandstones are divisible into two groups—

1. An upper or Cementstone group with subordinate freestones, dark grey and greenish shales, and thin impure bands of limestone and cementstone.
2. A Lower Freestone group; with strong freestones often coloured red or spotted with brown ochre, and associated with purple, lilac, green, and red shales frequently containing ochreous concretions.

To the lower group belong nearly all the Carboniferous strata north of the Silurian boundary fault; also a strip of the same beds on the south side of the fault in the main valley and good exposures in the Spithope and Cottonshope Burns. The upper group occupies the slopes of the valley and its branches south of the Silurian boundary-fault as far as another important boundary-fault — that of the cementstone group itself—which crosses the river at Cottonshopeburn Foot. Two inliers of the cementstones appear beside the same fault in the basin of Blakehope Burn, and there is one outlying cap away to the north in Hungry Law. In the greater part of Redesdale the line of division between these two groups nearly coincides with a contemporaneous outflow of trap, which will be fully described in another chapter.

The top of the Cementstone group appears to be more or less calcareous where it is best seen. In some places, as near Coomsdon Burn, it is marked by a fairly good limestone, creamy and compact; in otheir places such as Earl Sike, nearly opposite Catcleugh, by a kind of limestone conglomerate; and in others by swallow holes at the base of the Fell Sandstones. In the body of the formation the limestones in Redesdale are occasionally as much as four feet in thickness. A number of limestone bands or "posts" will be found at the head of the Sills Burn above Featherwood, in the eastern part of the Redesdale basin. One of these contains an unusual number of shells, such as *Rhynchonella*, *Orthoceras*, and smooth-shelled Lamellibranchs. Of coals there are throughout these groups almost as good as none. Two inches of coaly smut can be seen on fireclay in the Red Cleugh, the stream passing beside a cruciform plantation, nearly opposite Catcleugh; another shaly and smutty coal six inches thick lies in the streamlet descending into Spithope Burn at a point north from Windy Crag.

The thickness of this upper group in Redesdale may perhaps be taken to range from 300 to 400 feet; that of the underlying Freestone group from 200 feet to 350 feet. As the latter rests

Digitized by Google

unconformably upon the inferior formations its thickness may, of course, vary greatly.

Coquetdale.—The contemporaneous beds of Basalt that so nearly separate the Cement-limestone and Lower Freestone groups in Redesdale can be traced only to the head of Southope Burn, a little beyond the watershed. The division between the groups has not been carried out to the eastward. The sandstones, however, are still thick and red in the lower part. Halfway between Ridlees and Linsheeles the thickness of these strata, where they rest upon the lower rocks, is apparently much reduced; but this appearance may be deceptive. There are several faults in the neighbourhood (last seen crossing Byrness Hill and pointing a little north of east); these if continued in the same general direction (possibly to join a fault bounding the porphyrite in Ridlees Burn) would cross the district almost along the strike of the beds. These faults throw the strata down on their south side for several hundred feet. Their effect therefore would be to conceal a considerable portion of the lower beds of the Carboniferous rocks, and to obscure the relations of the groups now under consideration.

In Barrow Scar, a fine river-cliff of the Coquet east of Linsheeles, the beds of the Cement-limestone group have been laid open to a depth of about 200 feet. They consist of alternations of greenish shale, impure limestone, and thin sandstone. These strata are very variable in their character. Local unconformities, such as may be seen at the foot of Barrow Scroggs, 400 yards above Barrow,—rapid thinnings-out, like that of the Kay Heugh sandstone as it passes into Barrow Scar,—and discontinuous laminæ of plant remains and coal, as at the bend of the river 200 yards E.N.E. of Linsheeles, appear to bear witness to a good deal of contemporaneous erosion.

In the north-eastern corner of the map, beyond the Coquet, the strata below the Fell Sandstones have greatly thickened. The sandstones are still, in the main, subordinate and flaggy and speckled with carbonaceous matter; and the shales much tinged with distemper shades of green; but there is now superadded a strong development of buff and dun-coloured magnesian-looking limestones. These limestones are chiefly flaggy, and much banded with shale. Under the weather they are apt to assume a livid colour, and to develop dendritic markings of oxide of manganese. Most of them are richer in drusy cavities and concretions than in fossils, and they are often traversed by a network of rectilinear veins of calcite, as fine as pencilled lines. There are also a few limestones of a bluer colour, with small encrinites and corals.

This sudden development of flaggy limestones poor in fossils, thins out towards the north-east, only less rapidly than it sets in, and may be designated as the *Rothbury Limestones*. The general dip of these beds in this map is rather to the east of south, at from 4 to 7 degrees; and if we assume the limestone at Hepple

Digitized by Google

Kiln to lie 50 feet below the Fell Sandstones against which it is faulted, this limestone group must exceed 1,000 feet in thickness. At Farnham and under the Fells on the western side of the river the dip takes the westerly direction necessary to carry it under the Fell Sandstones.

Even in the lower part of the group, in the district between Alwinton Church and Burradon, there are many dark yellow and magnesian-looking limestones, with a few blue coralline bands. Some of the limestones have been burnt with good effect for field use, but the kilns are now deserted. The analysis of a magnesian limestone at Newton is given in detail.

*Analysis of Newton Limestone** (August 1872).

	Per cent.
Carbonate of lime	68·18
,, ,, magnesia	19·74
Sulphate of lime	3·74
Phosphate of lime	0·27
Silica	2·89
Oxide of iron	0·40
Alumina	2·50
Alkalies	0·44
Moisture, &c.	1·84
	100·00

In 1879 a trial boring for coal, (of which there is scarcely the slightest trace in this part of the Carboniferous formation,) was made about 630 yards south of Burradon Mains. The full details of the strata are not preserved. The bore-hole reached a depth of 25 fathoms; the first rock, which lay underneath two fathoms of stony clay, was sandstone six or seven feet in thickness, and the main part of the section was made up of bastard freestones and greenish shales like those of Barrow Scar. A limestone, in two bands, each about a foot thick and separated by shale, was met at a depth of about 20 fathoms. Another boring is given among the sections published by the Mining Institute of the North of England,† also without any trace of coal.

Boring in Burradon West Moor, for Mr. Thomas Clennell, July 1732.

	Ft.	Ins.
Grey metal	3	0
Open Limestone mixed with whin and water	4	0
Soft brown and grey metal	6	0
Grey post, mixed with whin and water	5	0
Brown post or Limestone	1	6
Grey metal with girdles or lumps	9	0
Limestone mixed with whin and yellow partings	7	0
Grey and black metal with post and whin girdles	24	0
Brown sand parting	0	9
Grey and blue metal	18	0
	78	3

* Received from Mr. Charles McSwarbeck, Chief Steward of Biddlestone Estate.

† No. 336 of Vol. I. The term *whin* in this section has no reference to igneous rock. It is commonly applied to any very hard stone, except limestone.

Digitized by Google

In the River Coquet, at Harbottle, above a rather massive and large-grained sandstone east of the Castle, limestones and cementstone-like bands are seen among soft greenish clayey shales, with, at the angle of the stream known as the Devil's Elbow, a single trace of red clay. Above Sharperton the river section is somewhat similar, and as follows:—

	Ft.	Ins.
Cementstone, in bands, with calc spar in drusy cavities - - - - about	10	0
Clayey bands - - - - - 4 or 5		0
Cementstone - - - - - -	1	0
Dark shale - - - - - -	0	6
Cementstone with *Stigmaria* - - -	0	9
Pale greenish shales, four or five feet thick, overlying some thickness of greenish shales with sandstone bands.		

The cementstone with *Stigmaria* is unusual. A little further down the river there appears one other characteristic section which also may be given.

Impure LIMESTONE with unrecognisable shells, small encrinites, and fragments of fish teeth (*Helodus*).
Soft green shales, about 20 feet visible.
Thin LIMESTONE.
Green clayey shale with a thin purplish band.
Sandstone, speckled with carbonaceous matter, with galls of greenish shale and many small plant stems, five feet.
Shale.
Cement stone bands, three feet.

Of the apparently non-magnesian limestones a blueish limestone of fair quality appears in the streamlet east of High Farnham, and contains small encrinites and comminuted fragments of shells. It is associated with carbonaceous-grey, instead of the more usual greenish, shale. Another blucish limestone, fetid under the hammer, is met at Low Farnham. Another, not less than 10 or 12 feet thick, is seen in an old quarry south of the house.

Probably the uppermost limestone of the group is the cream-coloured limestone of the Hepple Kilns at Hetchester.

Section of the Hepple Kiln Limestone.

	Ft.	Ins.
Limestone fragments - - - - -		
"Blue Stone," rather less creamy-looking than the rest - - - - - -	1	6
"Pebbly Bed," sometimes mottled with concretions	2	0
"White Rock," pure and cream-coloured -	5	0
"The Yellow," an impure argillaceous bed -	2	0
"Red Bed," weathering rather rusty - -	3	6
Dent (a shaly bed) - - - - -	0	6
Freestone - - - - - - -		

This limestone, too, is not without its few fossils, including a coral (*Chætetes, sp.*), a *Turbo*, a *Modiola*, and a *Cytherella*, all of indeterminate species. In the "White Stone" Mr. Kirkby recognises *Leperditia sub-recta*, J. & K., and another very robust *Leperditia* not far from the same species; in the "Blue Stone,"—

Digitized by Google

Kirkbya spiralis, J. & K., among a number of indeterminate forms. The limestone yields good "strong" lime, and the kiln is kept in constant use. A sample of the white rock quantitively analysed* has yielded only a trace of magnesia. The other beds of the section probably contain more. The bed described as the "pebbly bed" weathers out into an aggregate of little rounded pellets, and resembles oolite. This structure is concretionary. The Hepple Limestone is probably the same limestone that appears beside the stream at Holystone. The latter contains infiltrations of calcite, giving it some appearance of landscape marble.

The Cementstone Group in Whitefield Burn, Swindon Burn, and Dry Sike.—On the further side of the great Swindon fault with its 2,700 feet of northerly down throw, the upper beds of this group are repeated (*see* Fig. 1). They dip gently southwards from the line of dislocation. They consist of greenish shales, flaggy and ripple-marked sandstones (like those of Barrow Scar,) and magnesian-grey limestones of the Rothbury group. One thick limestone, pale, and buff-coloured, and non-encrinitic, spotted with concentrically ringed concretions, and with some tendency to form landscape marble, is seen in the Whitfield Burn. Another lies close beside the fault, in the Swindon Burn—a dun-coloured limestone; and another band, speckled with little crystals when freshly fractured, like a limestone in Southope Burn nearer Redesdale, is seen higher in the same stream. There are small exposures of the greenish shales and thin sandstones where these emerge from beneath the thick grits of the Darden Fells at Midgy Hall.

The Fell Sandstones.

(*Upper Tuedian.*)

The Fell Sandstones form a strongly marked and powerful group. The single beds that compose it occasionally exceed 100 or even 150 feet in thickness and the group altogether is a great feature in the configuration of the country, generally forming an elevated, moory, and desolate region, with ranges of heavy escarpment and broken crag.

These thick sandstones are commonly quartzose in texture, with their quartz grains, which are in the main composed of glassy quartz, often mingled with decomposing felspar and a scattering of rolled quartz pebbles of glassy, milky, yellowish and brownish varieties. The sandstones are coarsest towards the east of the map; towards the west the beds are much more finely grained. In a few places nearest the Cheviots they contain a little thin Cheviot-derived conglomerate or breccia. Under the weather their homogeneous blocks assume bulky rounded forms. In many places these grits and sandstones exhibit a gnarled-looking structure of contorted-like planes, an appearance very characteristic (among the Carboniferous bands of this county) of the Fell Sandstones, but not yet quite understood.

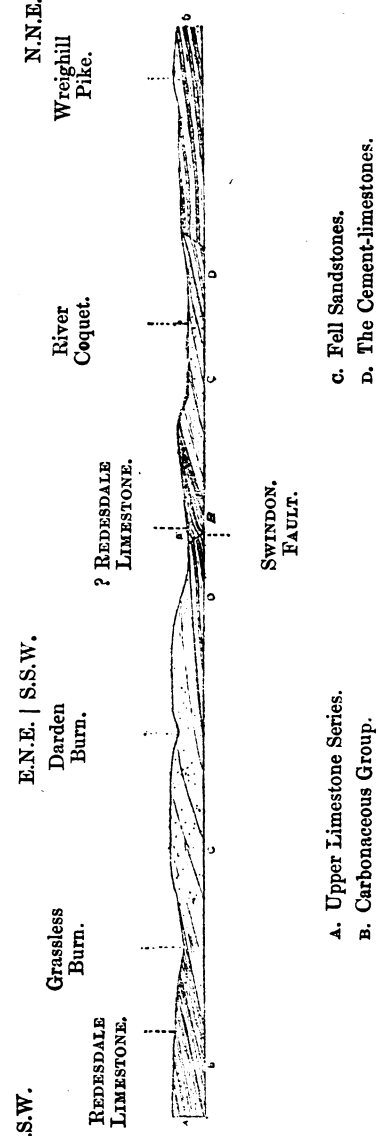
* By Mr. Jas. Grant-Wilson of the Geological Survey of Scotland.

Digitized by Google

FIG. 1.

Section across the Swindon Fault.

(Scale one inch to one mile.)



Digitized by Google

There is much strong current-bedding in the group, sloped, in the Harbottle Hills at least, chiefly from the N.E., and sometimes exemplified on what has been well termed a Cyclopean scale, a whole bed or beds apparently running out to nothing within a short distance. In attempting to trace out horizons, and in choosing the base-line of the group, it is therefore not always possible to keep to one bed. In colour the Fell Sandstones are whitish, yellowish, or brownish; and, rarely, blotched or banded with red. The softer and flaggier sandstones form the under parts of escarpments and waterfalls. Some of the thin sandstones among the shales of the group often possess the greenish distemper tints of the Silurian grits, and from these doubtless their materials were derived. The red and greenish marly-looking clays or shales with which they are associated are seldom to be seen except in open sections. Of limestones there are all but none; of coals, there are only two or three thin layers in the western part of the map, *i.e.* in Redesdale. A change comes over the beds towards the west. The grits are finer in grain; there are some dark shales, several coals, and some trace of marine fossils associated with them.

From the comparative poverty of feature-making beds in the underlying cementstones, the base of this massive Fell Sandstone group is much easier to delineate than its upper line or junction with the succeeding division. The latter is marked chiefly by the introduction of carbonaceous and coaly strata, with a greater number of limestones. It is doubtful, however, whether the former is in reality a much better division-line. Both top and bottom, in fact, are probably marked not by a line but by a passage from one series of conditions to another, and they may both, probably, vary in absolute horizon.

In following out some of the details of these beds we pass from east to west.

The Fell Sandstones in Coquetdale, from the E. side of the Map to Ridlees Cairn.—The more or less north-easterly strike prevalent in the strata throughout the southern part of Northumberland undergoes a powerful twist or *slew* along the west side of Coquetdale. From an east-north-easterly direction in Wilkwood Burn it suddenly, in the Harbottle Hills, trends to the south-east, and the heavy ranges of brown escarpment run parallel with the valley as far as the Beacon. Beyond the fault on the south side of the Beacon, which depresses the strata much more than it does further east in the valley, the strike of the beds resumes a more normal trend, *i.e.* nearly east. They cross Swindon Burn with the unusually high dip that accompanies their downthrow against the Swindon fault. Repeated on the south by this powerful dislocation the outcrops of the Fell Sandstones between Billsmoor Park and Whitefield Hill describe a rapid curve from south to east-north-east—the result of a twist back from a westerly dip into a southerly one.

Digitized by Google

The base-line of the group is concealed in the river by the Beacon Fault—a downthrow to the south of between 50 and 100 feet. Along the side of the dale this boundary-line is simply a line carried below the sandstone outcrops. It crosses the stream near Holystone under the sandstone of Rob Roy's Cave.* Westwards from the valley it is at first concealed by a fault with a downthrow to the south. It then stands out as a conspicuous escarpment extending into Redesdale, obscured only on the north side of Featherwood—perhaps by the continuation of the Byrness Hill faults referred to on p. 11. The top of the group, again, is very distinctly seen in Swindon Burn, near Donald's Bridge, marked by a thick false-bedded grit with rolled pieces of greenish shale; and again on the east side of Billsmoor Park. In some of the streams descending upon Wilkwood Burn from the south there appears to be a more gradual transition. This is illustrated in the following section, taken in descending order:—

Section in Wilkwood Black Cleugh.

Sandstone, fine grained; its lower part full of drift wood (*Lepidodendron, Knorria*, Coniferæ, &c.), 25–30 feet.
Shale, coarse, with plant impressions.
Flaggy Sandstone.
Shale, 5 or 6 feet, dark in upper part; pale greenish below.
Pebbly grit; a thin conglomerate at the base with schorl and porphyry: 2 feet.
Red Clay; in parts dark green and with calcareous knots.
Grit, partly pebbly, 10 feet.
Red Clay probably 10 or 20 feet.
Grit, 8 or 10 feet.
Red Clay, about 8 feet.
Grit, 8 feet; pebbly, with schorl, &c. at base.
Red Clay, much obscured, 40 or 50 feet.
Thick, coarse and massive grit, with some quartz pebblets.

This, it may be remarked, is the only good section of the Red Clays in Coquetdale. In the upper part of the group they appear to be much thicker than in the lower part, a fact again observed underneath Cold Law Kip, the highest point of the Harbottle Hills (marked by a cairn at 1,185 feet).

The thickness of the Fell Sandstones in Coquetdale is found to diminish considerably from the edge of the map westwards. Between West Hepple and Donald's Bridge in Swindon Burn the thickness of the group is estimated at not less than 1,600 or 1,700 feet. South of the Swindon fault again, about half a mile from the edge of the map, it appears to be nearer 2,000 feet; but if we take this same point at the base of the group and estimate the thickness of the group towards the *south-west* instead of the south, *i.e.* to the north end of Billsmoor Park, (which the rapid rolling over of the strata permits,) the group appears to amount only to 1,300 feet (Fig. 1); and in the Harbottle Hills it remains about the same, or rather less. No-

* This so-called "cave" is nothing more than a recess in the sandstone beside a waterfall.

Digitized by Google

where towards the west is it again even so much. In Carter Fell, a little beyond the Map, it is reduced to about 500 feet.

The excessive thickness of the group in Coquetdale is marked by the thickness and the coarse grain of its individual grits. A single massive escarpment beside the head of Darden Burn, for example, in a steep little runnel down its side, shows a clear 100 feet of rock. This escarpment, it may be remarked, breaks into four smaller ones when traced down stream. The grit of Dove Crag, south from Harbottle, considerably exceeds 100 feet; and another grit, nearer the village, (at the head of New Park Plantation), measures at least 160. In texture the grits vary considerably. The Dove Crag grit, for instance, is partly coarse-grained, partly pebbly, and partly felspathic; in its lower part it is false-bedded; its mid-strata on the other hand are laid out with very unusual evenness. Cleft by deep joints, hollowed by a stream into a precipitous recess, and weathered into little towers and domes by the atmosphere, this favourite retreat is a charming piece of rock architecture. In general the grits of the Fell Sandstones are open and absorbent in their texture. At least some of them, however, are said to "skin over" after passing from the hands of the quarryman.* A pebbly grit at Millstone Edge, beside Harbottle Lough, was at one time in great repute as a stone for millstones and the sharpening of scythes. Numbers of half-hewn millstones still mark the spot.

The source of the pebbles in these grits is quite unknown. They are the same wherever they occur all through the Carboniferous Limestone Series, *i.e.* of milky, glassy, yellowish, and brownish quartz, thoroughly rounded. The fine conglomerates of Cheviot-derived materials that have been alluded to are limited, in this Map at least, to Coquetdale; they seem to occur in most cases near the bottom of a grit. Several of these pebbly grits have been mentioned in the section of Wilkwood Black Cleugh. Another sparse and gritty pebble-bed with blunt-edged stones of schorl and porphyrite, mingled with the usual rounded quartz pebbles, occurs near the foot of Birky Sike, in Wilkwood Burn, and again, with jaspideous and quartzitic stones in the West Wilkwood Sike, above the house. The strong sandstone at the head of the Calf Lee landslip near Barrow Scar contains pebbles of Cheviot porphyrite, banded agate, and black tourmaline vein-stuff. In the River Coquet, 250 yards above its junction with Barrow Burn, there is a breccia made up mainly of pebbles of porphyrite, quartz, quartz vein-stuff with needles of black tourmaline, and fine grained granite like that of the Cheviots. None of the pebbles observed in these conglomerates much exceeds three inches in length.

* These Sandstones have not as yet, however, been very much quarried. The statement as to their behaviour after leaving the quarry I owe to Mr. Dowson, Senr., of Rothbury, who was engaged at the time in quarrying one of the escarpments towards the north side of the Harbottle Hills for a new bridge at Alwinton. They are probably best suited for bridge-building and other strong ashlar work. On the new railway from Alnwick to Cornhill the Fell Sandstones of Alnwick Moor are being found very serviceable.

Digitized by Google

The Fell Sandstones in Redesdale: from Ridlees Cairn to the W. side of the Map.—Passing over into Redesdale we find that while the general range of the Fell Sandstones remains easterly and westerly, and their base is still conspicuously marked by an entire change of features below the rim of the valley, the dip of the strata from Ridlees Cairn onwards has become much less regular, and is directed prevalently north or north-north-west; and that their southern boundary is a line of fault. This fault, which is the same as that which cuts off the Cementstone Beds towards the S.E., effects a great change in the appearance of Redesdale. (*See* Frontispiece.) Its downthrow is to the south, and so far as can be certainly ascertained, the strata along its downthrow side, between Ridlees Cairn and the west of the map, are entirely of the Carbonaceous group. On its S.E. side the slipping slopes in the valley (the Cementstones) are immediately replaced by ranges of bare sandstone scar, which strike at the fault in a very conspicuous manner. Even allowing for some considerable thinning of the Fell Sandstones in Redesdale—and in Carter Fell, six miles to the west of this fault, they are only 500 feet thick—this powerful dislocation does not probably fall much short of 1,000 feet.

Between Ridlees Cairn and the Dour Hills, which are the highest points of a great escarpment standing over Cottonshope Valley with slips and shot sandstone lying in immense confusion about its base, the ground is peaty and broken by block-strewn scars of grit. The northern boundary of the Fell Sandstones north and north-west of Featherwood may perhaps be a fault, prolonged from Byrness Hill. Dour Hill End is truncated by the large fault of Cottonshopeburn Foot. All the fells on both sides of Redesdale between this fault and that of the Silurian boundary are caps or masses of the Fell Sandstones.

The grits of Coquetdale have to a large extent given way to sandstones of ordinary grain. The scars, however, are still excessively strong and blocky, as for instance in the Countess, Ellis, and Windy Crags. Greenish composite beds derived from the Silurian grits are not uncommon. Red bands occur in Windy Crag, and red blotches east of the Great Dour. Some of the beds have a slightly calcareous character here and there. False-bedding is frequent and still affects whole features. It is not always possible to keep to one bed as the base of the group, but the horizon of the beds so taken does not probably vary much in Redesdale.

Purple and yellow shales and marls are seen a little above the base of the group in Coomsdon Burn, and in Ellis Cleugh in Blakehope. There are now a few thin "crow" seams of coal,—two in Coomsdon Burn, both resting on fireclay, and two at Chattlehope Spout, one of them a hard, bright, 8-inch seam below the massive bed at the top of the fall, the other about 50 feet below the capping of the second half of its long straggling descent.

Digitized by Google

CHAPTER IV.—CARBONIFEROUS LIMESTONE SERIES—*continued.*

The Carbonaceous Division.

This middle division of the Carboniferous Limestone Series in Northumberland is marked by its prevalent carbonaceous character, and by the presence of coal seams here and there throughout its whole thickness. With but few exceptions, traces of plant remains are found in all its beds,—in its yellowish sandstones, its dark, carbonaceous-grey shales, its calcareous grits, and even in many of its limestones. These limestones, therefore, were seldom formed at any distance from land. They are commonly thin, gritty or argillaceous, and more or less fetid. They are occasionally liable also to be current-bedded, ripple-marked, and even "worm-tracked"; these varieties graduate insensibly into a grey calcareous grit finely spangled with mica. Their encrinites, when present, are almost always small. Corals are rare. And, as has just been remarked, they often contain vegetable matter in the form of drift plants or charry-looking pieces of wood or the rootlets of *Stigmaria.* Perhaps the fossil especially characteristic of these limestones is *Rhynchonella pleurodon.* The number of Lamellibranch bivalves also is much greater in proportion to that of the Brachiopoda than is found to be the case in the better limestones of the Carboniferous Limestone Series.

A few beds of good marine limestone occur in the south-western portion of the Map. These mark the temporary introduction, by more rapid subsidences than those which accompanied the deposition of the larger part of the series, of conditions that in the Upper Limestone Series became regularly recurrent. They are also the certain sign of a gradual change in the relations of land and sea in passing southwards.

The great sameness of the strata, together with the obscurity of the ground, render it impossible to trace out the Coals and Limestones of this group much beyond the spots at which they have been actually seen or worked, and the sandstones are found so to dovetail among one another and the shales as to defy separation. The details in consequence have not been made as intelligible by means of connecting lines, as might be desired. In the eastern part of the map the Carbonaceous Division distinctly represents and strongly resembles the Scremerston Beds of north-east Northumberland. In and near Swindon Burn its limits are well defined, and its thickness is little more than the average thickness of the Scremerston beds—about 1,000 feet. Towards the south-west, its lower limit becomes much obscured, and would be difficult to define except by a mere group-line;* it becomes considerably less like the coal-measures, with *crista-galli* markings and more

* Up to this present time the line has not been drawn.

Digitized by Google

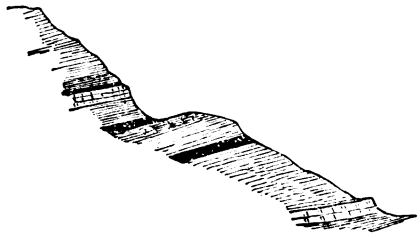
numerous marine fossils; its limestones gradually increase from a few thin bands to many dozens, including as has been stated, two or three fairly good thick beds; and towards North Tynedale in this Quarter-Sheet its thickness cannot much fall short, if at all, of 2,500 feet.

The rapid alternation of the thin bands of limestone and coal, and the generally *carbonaceous* type of the division, are illustrated by the following section (Fig. 2) of a small coal-and-limestone group at Midgy Holes in Tarset Burn. It contrasts strongly with the ordered cyclical arrangement of the zones of the Upper Limestone Series (Fig. 3, p. 43).

FIG. 2.

Section of Carbonaceous Beds at Midgy Holes, The Comb, Tarset Burn.

(Scale 1 inch to 24 feet.)



	Ft.	In.
Shale		
LIMESTONE, with cone-in-cone structure	0	2
Shale, dark	about 4	0
COAL, dull, like Cannel Coal; its planes crowded with crushed Entomostraca	2 ft. to 2	4
COAL, glossy Free Coal	3 ins. to 0	4
LIMESTONE	1 ft. 6 ins. to 2	0
COAL, inconstant	3 ins. to 0	4
Shale	3	0
COAL	0	9
Fireclay	4	0
COAL, 1 foot of it seen, full thickness not known	1	0
Obscure, with shale	10	0
LIMESTONE, partly creamy looking, partly dull red: Cyprids* and traces of *Stigmaria*	1½ ft. to 2	0
Shales		

* Some of these Entomostraca have been determined by Mr. J. W. Kirkby,—*Leperditia Okeni*, Münst; *L. subrecta?* Portlock; *L. scotoburdigalensis*, Hibbert; *Cytherella extuberata*, Jones & Kirkby; *Carbonia fabulina*, J. & K.; and *Beyrichia or Beyrichiopsis* sp, large. The Cyprids of the Cannel Coal are so much crushed as not to be determined with satisfaction. A punctate valve is very common among them, possibly belonging to *Carbonia fabulina*. Other valves look like *Cytherella extuberata*, *C. attenuata*, J. & K., and *L. scotoburdigalensis*.

Digitized by Google

It must be remarked, however, that neither cannel coals nor cone-in-cone structure in limestones is characteristic of the Carbonaceous group, both being in fact rare. Nor is it common to find a limestone actually lying between two coals, as in this case.

The Carbonaceous Group in Coquetdale.

Such details of this large group as need here be described, concern first the eastern part of the Map, where its limits are best defined. Beginning from the east, it is first well seen in the Swindon Burn. It then strikes more obscurely westward to a considerable fault that crosses Elsdon Common from the north-east and that throws the strata down on the west. Near Yardhope it is very imperfectly seen; but it again forms a distinct group between the Fell Sandstones and the Upper Limestone Series on the south side of Wilkwood Burn. South of the Swindon Fault it appears above the Fell Sandstones in Billsmoor Park.

Neighbourhood of Swindon Burn, Ovenstone, and the Crag.—In Swindon Burn these beds are found dipping south at 20 and 25 degrees to the Swindon Fault, against which they lie in a violently crushed, and for a few yards inverted, condition. They appear to be about 1,100 feet thick as estimated (1) from the base of the group, below Donald's Bridge, to the Swindon Coal (a thickness which is taken as 620 feet), and again (2) from the out-crop of the same coal at Hepplewoodside gardens to the limestone in the ravine 300 yards south of the house, which, though the beds are not continuously seen, appears to include 500 feet. This limestone is probably the bottom limestone of the overlying group (Fig. 1, p. 15). The greater part of the beds in Swindon Burn consists of carbonaceous shales and fine-grained sandstones,—sometimes ripple-marked and tracked by crustaceans and worms—associated with a few calcareous grits, several quite thin limestones, and some coal seams. Only two limestones can actually be seen,—a band near the base, one foot thick, with bivalve shells resembling *Myalina*, and another of shelly limestone, a foot thick, with an inch of bright coal in the middle of it, which lies, all full of strings of calcite, crushed against the Swindon fault. There are three coal seams of which the outcrops are known—the Donald's Bridge Seam, near the bottom of the group, a layer only 9 inches thick, but at one time worked apparently with profit; the Swindon and Ovenstone Seam—a triple seam with two bands, together from 3 feet 2 inches to 3 feet 4 inches thick; and the Hepplewoodside Seam, which consist of 3 feet of good coal. East of the Swindon Burn these coals were lost. There is a single line of old coal pits into the Swindon Seam on the north side of Whitefield House, just where the beds are striking against the great fault. The following is a section of one of the old pits above the Swindon Coal, probably further west. Its exact site is unknown.

Digitized by Google

*Pit Section of the Strata above the Swindon Coal.**

	Ft.	in.
Yellow Freestone	24	0
Coal	1	0
Grey Metal Staits (? Metal stone)	6	0
Grey Freestone	3	0
Light Blue Metal	6	0
Coal	0	2
Ironstone called "Lizard stone"	0	8
Coal	0	2
Grey Metal	2	0
Greystone	4	0
Light Grey Metal	3	0
Ironstone, or "Lizard stone"	2	0
Blue Metal	6	0
White Honestone	1	8
Blue Metal	4	0
Beddy Freestone	6	0
Blackstone mixed with Coal	2	0
	ft.	in.		
Coal	0	8		
Chalkstone, very hard	0	6		
Coal	0	9	2	9
White Metal	1	0		
Coal	0	10		
			75	5

It will be seen from this section that there are coal seams of which the outcrop is unknown. The "ironstones called Lizard stones" are probably impure limestone bands. The main coal seam has been worked on both sides of the Grasslees Burn, but was abandoned about a mile to the westwards, having become disturbed and much flooded with water. The Hepplewoodside seam, again, was lost half a mile to the north of Grasslees Mill. Many attempts were at one time made to find these seams by means of borings near the Crag, but these met with no success. The only seam worked near the Crag was a 10-inch seam opened out for some yards beside a fault in Keenshaw Burn.

Having passed thus far westwards we already remark an increased number of limestone bands, some of them containing the rootlets of *Stigmaria*. A limestone apparently of some little thickness—with cyprids and traces of plants, has been quarried on the moor at Piper Shaws.

Neighbourhood of Billsmoor Park.—In Billsmoor Park, south of the Swindon fault, the Carbonaceous Beds, though but imperfectly seen, appear to retain their thickness of about 900 feet. (See Fig. 1, p. 15.) A coal seam, reported to be 4 feet thick, has been worked in the Grasslees Burn at Billsmoor Foot, and again in the Grasslees Wood—in both cases within a very short distance of a line of fault which must bring them against much higher beds. A 16-inch seam, a little higher in the group, underlies the waterfall descending over sandstone at Billsmoor Foot; and

* I am indebted to my colleague Mr. Topley for this section.

Digitized by Google

two or three small seams of 6 and 8 inches have been opened into in Billsmoor Park. Coaly layers, "crow coals" and "smuts," seem to be numerous. One or two thin cementstone-like limestone-bands with bits of plants are seen south of the park, opposite North Riding.

Carbonaceous Beds near North Yardhope, and on the South Side of Wilkwood Burn.—On the further side of the north-easterly and south-westerly fault already referred to as crossing Elsdon Common, the relations of the Carbonaceous group are obscure. A Coal of unknown thickness has been worked at some time very long ago among coaly shales near North Yardhope. The beds are probably faulted in between the Fell Sandstones on the east and the Upper Limestone Series on the west.

On the south side of Wilkwood Burn the thickness of the beds between the grits of the Fell Sandstones and the bottom limestone of the Upper Limestone Series can be fairly estimated at about 1,000 feet. On the east they are evidently faulted against Fell Sandstones near the ruined hut known as Wilkwood Pit House. Two 13-inch coal seams were formerly worked near East Wilkwood. Another seam, of which the thickness is now unknown, is marked by a line of old crop-pits in Ramsay Cleugh. A number of "crow" coals and thin limestone bands, some of them cementstone-like and containing cyprids and fragments of plants, lie in in the same ravine. The Carbonaceous Beds also appear in a condition of great disturbance in Coal Sike, one of the head streams of Wilkwood Burn. They must then pass over into the basin of Redesdale.

The Carbonaceous Division in Redesdale.—In the main valley of Redesdale the Carbonaceous group extends from Cottonshopeburn Foot down to Bagraw. But there are no good sections. The character of the strata is better seen in Sills Burn, Bellshield Burn, Hindhope Burn, Ralph's Cleugh in Blakehope, and the upper part of Wind Burn. The thickness of the group in Redesdale cannot be rightly ascertained. Near the eastern watershed of the basin the section, moderately computed from a point about a mile south of Ridlees Cairn and across Corby Pike to the Upper Limestones near Ridley Crag, appears to exceed 1,000 feet. This is not the whole series, and the beds have certainly thickened. The sandstones appear in stronger and more numerous beds, and are less uniformly fine grained; the two or three limestone bands of Swindon Burn have increased to a considerable number, some of them now encrinital; the coal seams also appear to be much more numerous. The dip along this north and south line is to the southward, and remains south or south-easterly as far as the valley, except that between Bellshield Burn and the Cottonshopeburn Foot fault it rolls over to the north-west. In the valley above Rochester we meet with an

Digitized by Google

important synclinal hollow running north of west from Birdhope Crag to Black Blakehope. To the south of that line, over the whole S.W. corner of the map, the prevalent dips are northerly, and it is only on the east side of the Tarset Burn that they make as if to pass under the upper limestones.

In Black Burn at the head of Sills Burn, beside the Cottonshopeburn Foot fault (more euphoniously known as the Dour-hill-end fault) we find several exposures of coal and limestone, all in a disturbed condition, and all probably on the south side of the fault. One of the coals lying furthest up-stream is reported to be two feet thick. One of the limestones is of good quality, containing some *Lithostrotion* and lying in the stream brightly polished by its action. Above Pity Me, a little lower in the Burn, there are old crop-workings into a coal of unknown thickness. Still lower down, near the house, there is a section which may be quoted :—

Section in Sills Burn at Pity Me.

	Ft.	in.
Shale, with one or two thin coal seams, about	15	0
Sandstone, fine grained	4	0
Shale, about	18	0
Limestone Conglomerate (?), with fish teeth, scales, &c., containing encrinites, *Orthoceras*, *Rhynchonella*, *Spirifera*, bivalves and *Naticopsis*	1	6
Shale, with Coal, 1 foot	12	0
Shale, with an impure limestone band with a *Naticopsis*, about	10	0
Sandstones and Shale in courses with plant remains (*Lepidodendron*, &c.).		

Limestone conglomerates, such as that contained in this section, occur here and there throughout the Carbonaceous Division, always in thin bands. It is very difficult to distinguish them satisfactorily from concretionary limestones, but the balance of evidence, after careful examination of a great number of them, is in favour of their being at least in some cases conglomerates.

The lower parts of Sills Burn, and its eastern branch, Little Sills Burn, abound in limestones and coals. The coals may be just enumerated.

1. A 14-inch seam laid open beside a sheep-fold at the head of Little Sills Burn with a section as follows :—

	In.
Coal	6
Band	4
Coal	4

2. An 8-inch seam exposed at the large elbow of the same stream three-quarters of a mile further down.

3. A 2-foot seam reported to have been seen under a sandstone beside the main stream exactly two-thirds of a mile above Silloans.

4. A seam of unknown thickness, at one time dug into at a point 200 yards up a side stream that enters Little Sills Burn from Long Fell, an escarpment lying to the eastward.

Digitized by Google

5. A 2-feet seam of good coal, recently worked in shallow shafts a short distance further up the same sike. The section of this coal can be given in detail, as measured in one of these open pits :—

	Ft.	in.
Calcareous grit, full of casts of *Rhynchonella* and *Spirifera*		—
Obscure		—
Shale		—
Coal	0	5
Shale	1	6
Coal, with one or two inches of band	2	2

6. Coal, 9 inches to one foot thick, in Little Sills Burn, 900 yards above Silloans; broken.

7. Coal, a short way above a thin limestone, a few yards further down stream; 9 inches.

8. A 14-inch seam near the wall of the infield of Sills Farm, having the following section :—

	In.
Coal	6
Band	3
Coal	5

9. An outcrop, marked by pits, on the bank above the three seams last named, thickness of seam unknown.

All these seams are probably associated more or less closely with bands of limestone and calcareous grit. The relations of the seams noted under 6, 7, 8, and 9 to those numbered 3, 4, and 5 are unknown. An E.S.E.–W.N.W. fault may possibly separate them, but this is uncertain. Nos. 1 and 2 might perhaps be the same. The surface of one of the limestones nearest Silloans is well ripple-marked.

It is probably the same Coal group that appears at High Rochester on the further side of a fault passing Ridley Crag; but the details of the section cannot be identified. Of this group an upper seam, stated to be 2 feet thick, has been much worked, under the name of the Bush Seam, north of the Roman camp of Bremenium, as well as at an earlier period, 60 or 70 years ago, under the sandstones of the Huel Crag, some distance back from its broken front.

The section is preserved in the account of an old boring published among the Records of the North of England Mining Institute. This is probably the old borehole still lying open in front of the little house, near High Rochester, known as the Bush or Craw Bush, on the east side of Sills Burn, and entering the surface in bare sandstone about 90 feet above the coal.*

Account of the Boring at Borehole No. 4 in Sills Burn, at Birdhope Craig Estate.

1805.

	Ft.	in.
White Freestone	46	0
Strong White Post	7	0
Yellow Clay	0	7
Grey Metal Stone	3	5

* Borings and Sinkings, vol. i., p. 141. This point lies a little *east* of Birdhope Crag Estate, which is bounded by the Sills Burn. Anywhere on the west side of the stream the borehole must have entered in boulder clay.

Digitized by Google

	Ft.	in.
Hard Whin	1	6
Small White Post	0	3
Blue-grey Metal	12	6
Black metal mixed with *Coal*	0	5
Grey metal stone	6	10
Bluish metal	2	8
Coal	0	8
Blue metal	0	5
Coal	0	7
Hard blue metal	3	2
Hard grey stone	1	2
Coal	2	0
	89	2

A 9-inch seam lies about 4-fathoms lower, under an impure limestone band, and has been worked beside the Sills Burn. Besides these there may be mentioned two others—a coal 10 inches thick in Coal Cleugh, a little north from Dyke Head and a few feet under 1½ foot of fetid limestone containing *Stigmaria* rootlets; and a coal at Dyke Head bared in front of the house, but of inferior quality. A little below the last-named there is an impure marine limestone containing some corals (*Lithostrotion*).

Above Birdhope Crag at Bell Shields a coal has been worked under the table of sandstone at Bell Shield Crag. The old pit-heaps dot the interior of the large square camp marked upon the map, and skirt the foot of the crag and the side of Bell Shield Burn for about half a mile above the bridge. The section is stated to have been as follows:—

	Ft.	in.
Sandstone	36	0
Shale	6	0
Coal	0	10
Band	0	4
Coal	0	6
Band	2	6
Coal, with about 3-inches of band	2	0

The general section has much resemblance to that of the Bush Seam north of High Rochester. The two sets of workings are separated by an obscure drift-covered tract lying east of Birdhope Crag Hall, but the journals of the borings, of which one has been cited, place their identity beyond much doubt. The following is from a point 550 yards north of the House:—

	Ft.	in.
Soil and Sand	1	3
Yellow Freestone	36	0
Strong White Post	6	0
Yellow Freestone	11	9
Strong white post, mixed with whin	8	0
Strong white post	3	0
Dark brown post, with whin girdles	3	0
Strong yellow clay or soft metal	1	3
Blue-grey metal	10	3
Coal	0	6

Digitized by Google

	Ft.	In.
Blue-grey metal	0	5
Coal	0	6
Blue-grey metal	7	0
Coal	1	3
	93	2

Four other sections will be found in the Appendix. The coal varied from 1 ft. 3 in. to 2 ft. 1 in. In both cases a 9-inch seam has been worked a few fathoms below the larger coal.

The relation of these coal seams to the sandstone ridges that strike in a westerly direction between Bellshield Burn and the large Dour-hill-end fault cannot be clearly ascertained. There is, however, a 4-feet gritty limestone resting upon six inches of coal west of Bellshield Law which strikes westward as if to occupy a position well up among these sandstones. On this and other grounds they are taken as probably belonging to the Carbonaceous group.

Opposite Bell Shield, beyond the river and on the further side of the syncline, there are one or two sandstone escarpments rising southwards into long inclines answering to dip-slopes. The Bellshield coal may underlie one of these sandstones. Two coals appear along the strike of the beds towards the west. The one is marked by the Black Blakehope Pits in Ralph's Cleugh, and has a massive sandstone a short way above it and shales with calcareous beds not far below. The position of the other is conspicuously indicated by the pit heaps at Hillhead, and probably also by those of Rooken-pit-house. The Black Blakehope pits were started about the year 1831, and continued working for 11 years. The seam is said to have lain in two bands—an upper band of very good coal, separated from a lower and thinner one by a thin but very hard parting. The section is given, perhaps not very reliably, as follows:—

	Ft.	in.
Top Coal, good	1	11
Hard Whin Post		9
Coal, about		8
	3	4

The parting is said to have become latterly so thick as to give more trouble than the coal was worth.

The other two ranges of old coal-workings referred to—those of Hill head and Rooken-pit-house, are separated only by an obscure interval of about 400 yards, at about half a mile S.S.E. of Hillhead. This interval is probably occupied by a north and south fault that is seen in a stream a little to the southwards. The Hillhead seam is stated to be 18 inches thick. Half a mile to the westwards, near the head of Hindhope Burn, there are traces of pits that may mark its continuation in that direction. The Rooken-pit-house seam is two feet thick, and has been worked in pits as much as 16 and 17 fathoms deep. It undulated with

Digitized by Google

a low variable dip, throwing the coal into little basins which the pitmen called "swellies." North of East Rooken-pit-house this coal became of inferior quality. South of the Wind Burn it is unknown.

Before passing on to the basin of the North Tyne there are a few other coal seams in this district which may be at least enumerated. A coal seam, thickness unknown, lies to the south of the Wind Burn a little below the probable position of the Rooken-pit-house seam. Another coal, said to be 16 inches thick, was worked about a century ago at an elbow of the Wind Burn a mile above the Rede. A seam 14 to 16 inches thick, recently worked half a mile to the southwards of this spot, is perhaps the same coal brought back by the reversal of dip from north into south. A coal said to be 1 foot 8 inches thick was worked on the south side of a considerable fault with a southerly down-throw at Kelly's Pike, half a mile south-east from Rooken. And at Gorlees Crag, beside Gib Shield, there is a seam 16 inches thick open to inspection in the mouth of a level. Several small "crow" seams were much dug into in Bagraw plantation near Horsley before the wood was planted—scarcely within memory; one of them is very doubtfully reported to have reached a thickness of 20 inches. The character of the Carbonaceous strata, with their little coals and fetid calcareous beds containing cyprids, *Myalina*, &c., is well marked in this place. The following section in Wind Burn is also worth a note before passing on:—

Section South of Wind Burn, half a mile West of Rooken.

	Ft.	in.
Shale, with coarse bands of calcareous ironstone, containing *Myalina*, sp., *Rhynchonella pleurodon*, *Sanguinolites*, sp., &c. - - - -	15	0
Coal - - - - - -	0	6
Shale with *Stigmaria*, about - - -	8	0

The Carbonaceous Division in the Basin of the North Tyne.— The strata of the south-western quarter of this map belong almost entirely to the Carbonaceous Series; spreading out with a variable northerly dip, and turning in eastwards under the Limestone group east of Tarset Black Burn. The thickness of these beds cannot be fully estimated. It is certainly much greater than in Coquetdale. Thus, in Black Burn in Tarset, from a base perhaps 600 or 700 feet above the bottom of the Division to a point on Blackburn Common probably at least 200 or 300 feet below its upper limit (which is there obscured by faulting,) there appears to be about 1,700 or 1,800 feet of strata. This doubtful, or perhaps more than doubtful, estimate, *i.e.* a total thickness of about 2,600 feet for the group, is the nearest that can be arrived at. It will be

Digitized by Google

seen later on that the bottom of the Black Burn section is placed 600 or 700 feet above the bottom of the group on evidence not very strong, of which is to be reckoned as not least the necessity for keeping the total thickness of the group within bounds; but the result agrees very well with that arrived at from cumulative evidence on the ground further south, in Quarter-sheet 106 N.E.

While thus swelling out the group has also continued to change in its general character. The coals are much as in Redesdale, but probably still more numerous. The limestones have, on the whole, both increased in number and improved in quality; two or three of them, from 5 to 11 feet thick, are purely marine, and yield good lime. Such are the Pipers Cross Limestone, the Plashetts Dun Limestone, and the Productus-limestone of Belling Burn just west of the map. But the greater number are still "bastard" limestones, mingled with gritty and argillaceous matter, and frequently containing fragments of plants or actually penetrated by rootlets (*Stigmaria*). Limestones such as these may be seen at Midgy Holes in Tarset Burn, a mile above the Comb Farmhouse. (Fig. 2, p. 21.)

It is still found impossible to trace any of the beds continuously through the district. Faults are numerous; large parts of the ground too are covered by drift, peat, and growing vegetation. It is probable, however, that the succession of the strata falls into two parts,*—a lower series of beds, with the Plashetts Coal about the middle, and with two fairly good marine limestones, the Piper's Cross Limestone (the top of the group,) and the Plashetts Dun Limestone, in its upper half; and an upper series of sandstones and shales, with plenty of impure limestones, calcareous grits, and small coals, but not containing any single beds of special import and, in fact, to some extent characterised by their absence. Each of the groups may contain from 1,400 to 1,500 feet of strata.

Lower Group; from the bottom of the Carbonaceous Division to the Piper's Cross Limestone.—Among the lowest known beds of the Carbonaceous Division in North Tynedale are the Coals of Lewisburn, about 6 miles due west from Falstone. This little Coal-group probably comes almost immediately on the top of the massive sandstone series (Fell Sandstones,) of Peel Fell. About 500 feet of sandstones, shales, coals, and impure calcareous flagstones bring us up to a somewhat distinctive Productal limestone, which lies in the stream half a mile below Lewisburn High Long House. This may be the same Productal limestone that occupies the bed of the Belling Burn close beside this Map; and the four coal seams above the Belling Burn limestone may represent some of the higher Lewisburn Coals.

* This division has little or no stratigraphical value. It is adopted mainly to facilitate description.

Digitized by Google

The following section may be taken as representing at once the structure of the Falstone district, and the section of this lower group of the Carbonaceous Division.

General Section in the District of Falstone.

	Feet.
Sandstone - - - - - -	
Shale, 45 or 50 feet.	
Limestone, *Pipers Cross Limestone* - -	11
Massive Sandstone, about - - -	50
Strata - - - - - -	250
Sandstone, about - - - - -	20
Shale - - - - - -	20
Limestone, *Plashetts Dun Limestone* - 2 feet to	5
Strata - - - - - -	90
Coal, *Plashetts Seam*, average thickness about -	4
Strata, containing the *Shilburnhaugh, Starslee*, and *Belling Crag Seams* - - - 500 to	600
Limestone, at the foot of Belling Burn (probably the Productus-Limestone of Lewisburn) -	10
(Sandstones, Shales, Coals, and impure calcareous flagstones, at least 500 feet thick in Lewisburn) -	500
	1,560

Coals under the Plashetts Seam.—Of the four seams under Belling Crag, the uppermost, 1 foot thick, enters the Map at the railway. Overlying strata are seen in Starslee Burn, including two limestones, one of them containing rootlets of *Stigmaria*. A coal known as the Starslee Coal has been worked further up the same stream; its site is marked by old shafts, but its thickness is not now known. It may not improbably be the same as the Shilburnhaugh seam. The Shilburnhaugh seam is an excellent house coal, best known to the south of the river near the top of the long moory bank, broken by sandstone ridges, that faces Whickhope Burn. The general section of this seam is best known in an air shaft a few hundred yards to the south of the Map, as follows:—

	Ft.	In.	Ft.	In.
Sandstone - - - - - -			46	0
Shale - - - - - -			27	0
	ft.	in.		
Coal -	1	2		
Band (Shale)	1	6	- - -	3 10
Coal -	1	2		

The escarpment of this overlying sandstone enters the Map in the extreme S.W. corner, and turns round eastward by the river side. The bottom seam, which produces good *round* coal, has thinned away to 4 or 6 inches between the river and the North Tynedale Road. This has been proved in recent bore holes and a trial level. The workings have not therefore been prosecuted north of the road. A hard gritty grey limestone (or calcareous grit), rich in *Myalina* and *Sanguinolites*, was found in the level, probably below the seam. The same coal, with its full section, has

Digitized by Google

been worked south of Yarrow in Shilling Pot, a bleak hollow traversed by the road. A northerly dip at that point sends a confusion of shot sandstone down on the south side of the hollow, but the roof of the coal was good. Coals of the same thickness and lying in two similar bands have been worked in the bank under Falstone Railway Station and in Hawkhope Burn above the railway. The Hawkhope coal was a good steam coal. To account for the presence of the Shilburnhaugh seam in Hawkhope Burn in the same line of strike with the Plashetts seam, as we shall see, in Carshope Plantation, it is necessary to suppose a considerable fault to pass between them with an easterly downthrow. There is the same necessity further north in the position of the Plashetts Coal, at the east end of the Plashetts workings, relative to the Piper's Cross Limestone in the Hawkhope Burn. There can be no difficulty in admitting this dislocation, which must cross Hawkhope Burn near Hawkhope Plantation.

The Piper's Cross Limestone has been at one time quarried and burnt on the side of the fell north from Hawkhope Hill. The blocks that remain about this grass-grown quarry are bluish-grey and encrinital, with a sub-conchoidal fracture and, evidently, of excellent quality. In a stream further west the limestone is partly decomposed into ochre. Its best sections in this Map are in Hawkhope Burn. In one of these it is 11 feet thick, and rich in encrinites, *Productus giganteus*, and junciform corals; in another it is no more than 7 feet thick, and passes down into the underlying sandstone through some calcareous grit with *Rhynchonella pleurodon* and many Spirifers. The same limestone can be just detected at the edge of the Map, out towards Earl's Seat under the sandstone of Rabbit Crag, and the "edges" of some of the sandstones are displayed in a regular descending series from there to the Plashetts Coal at the Black Belling. The upper part of the above section is estimated along this line through an air shaft into Plashetts Colliery, the details of which are given below.

The Plashetts Dun Limestone accompanies the Plashetts Coal in every good section. It is always brown, whence its name. In the Falstone Burn it has yielded excellent lime for the Falstone Bridge and other buildings; at other points it is much decomposed.

The Plashetts Coal.—The details of the strata associated with the Plashetts seam are best known in this Map at Carshope Plantation half a mile north from Falstone.

*Section at Carshope Plantation.**

	Ft.	In.
Sandstone, thick - - - - -		
Shale - - - - -	20 to 25	0
LIMESTONE, decomposed and ochreous, *Plashetts Dun Limestone* - - - - -	2	0

* This section is from measurements made on the ground, supplemented by a boring in the lower part. For this boring, and for much information respecting the coal seams, &c., of this district, I am indebted to MESSRS. MICHAEL ROBSON AND SONS, of Falstone, the lessees of the Shilburnhaugh pits.

Digitized by Google

	Ft.	In.
Sandstone	3	0
Shale	7	0
Sandstone	21	0
Shale	60	0
Coal, *Plashetts Seam* — 3 feet to	3	6
Shale, with Sandstone bands — about	50	0
Sandstone (*Greenies Cray* Sandstone)	30	0
Shale	15	0
Coal, "*Small Seam*"	1	0
Shale, with one or two thin bands of impure limestone.		

The underground workings of the Plashetts Coal Company enter the area of this Map north of Black Belling (the summit of which is 1,060 feet above the sea) on Hawkhope Moor. A single air shaft is all that appears at the surface.

Section in an Air Shaft 700 yards north by east from Black Belling.

	Ft.	In.
Surface and Freestone	12	0
Blue Metals	45	2
Limestone, *Plashetts Dun Limestone*	4	3
Freestone, with soft partings	22	2
Blue Metal, mixed with post	18	6
Whin	3	3
Grey Metal	3	6
Whin	0	10
Blue metal, strong	2	0
Coal	0	6
Saggar and plate	13	5
Grey metal, hard	0	6
Coal, Plashetts Seam — Ft. In.		
Coal 2 4		
Shale 0 2	3	9
Coal 1 3		
	129	10

The coal as worked in this map west of the Hawkhope Burn varied from 3 feet or less to 5 feet 2 inches. It was associated with iron pyrites, quantities of which were at one time sent away from the pit mouth. The coal itself has the reputation of being in parts "brassy," and, like most of the coals of the group, burns with a quantity of ash. The workings were prosecuted eastwards against a fault filled with a soft, pale-grey, earthy substance which was known as "the Plashetts plaster"; from the composition of this substance (see p. 100), as analysed by the late Rev. Hugh Taylor of Humshaugh, it must have been a basalt dyke. The coal near it was cindery and worthless, and the workings followed the side of the fault without proving it. It must however send an important branch across the Hawkhope Burn, about 300 yards S.S.E. from where the workings terminated, crossing doubtless beside a veined and shattered sandstone that can be seen dipping N.E. at 20 degrees.

This is quite certainly the same fault with southerly downthrow that gives us the outcrop of the Plashetts Coal twice over in the

Digitized by Google

ascending section of Falstone Burn. In Falstone Burn it contains a basalt dyke in the ordinary crystalline condition. This fault also, as has been partly shown, brings the Piper's Cross Limestone from the eastern uplands of Hawkhope Moor down into the bed of the Hawkhope Burn, where it is exposed in open sections as given in the general section on p. 31. The Plashetts coal in Hawkhope Burn is unknown, being nipped out by another branch of the fault. The outcrop of the Piper's Cross Limestone, it will be remembered, is bounded by faults both at its upper and lower end and on its west side (see Chapter on Faults, p. 79).

Half a mile to the east, in Carshope plantation and beyond it, the coal has been much worked. The section has already been given. From there to beyond the parish boundary, east of the Falstone Burn, it is from 3 to 3½ feet thick. In the neighbourhood of Falstone Burn there is a section of about 700 feet of strata, from a group of sandstones lying about 250 feet below the coal to a point about an equal distance above the Plashetts Dun Limestone. The limestone, which is detected resting on a sandstone full of large roots of *Stigmaria* beside an old limekiln, has yielded some excellent lime for local purposes. Old levels to the coal can be traced beside the stream lower down. At the head of the stream the same fault which further west contains the "Plashetts plaster" is now occupied by a basalt dyke, 50 or 60 feet broad; and the coal is repeated on its north side. It is here 4 feet thick; it has its usual two inches of shaly band, and its characteristic hard flaggy roof; besides an overlying fossiliferous shale with a plentiful scattering of *Leda, Axinus, Pteronites, &c.*, certainly the same that may be seen in the stream near the site of the old coal levels at the other outcrop lower down. The Dun Limestone on the top of a long bank of sandstone and about the usual distance above, terminates the section. The presence of this fault was long since well known to the late eminent mining engineer, MR. T. J. TAYLOR.*

The following detailed section was taken in a shallow open shaft at the head of the Falstone Burn.

Falstone Burn Head: Section above Plashetts Coal.

	FEET.
Shale with *Leda attenuata*, &c. - - -	8 to 9
Shale with *Cypris* bands (*Leperditia scotoburdigalensis*), plants, and *Lepidostrobus*: hard, calcareous, and flaggy in lower part - - -	5
COAL (not visible) - - - - -	4
	18

* To some valuable information in the papers of this gentleman I obtained access through the kindness of my late lamented friend the REV. HUGH TAYLOR, of Humshaugh House, and the courtesy of the other trustees of the late Mining Commissioner to the DUKE OF NORTHUMBERLAND, MR. JOHN TAYLOR, of Earsdon.

Digitized by Google

The coal is privately worked. MR. T. J. TAYLOR gives its section as follows:—

	Ft.	In.
Roof, blue metal, good		
COAL	2	11
Coaly Band	0	2
COAL	1	2
	4	3

"There is a bed of cannel coal," he adds, "above the seam, about one foot in thickness, but not regular."

Towards the east the fault just referred to is not known. It is probably connected with a fault of much more southerly trend that bounds the old coal workings of Thorney Burn (a little south of this map) on their west side. But on the east or north side of the fault the Plashetts Coal is not again with certainty recognised. On its south side, *i.e.* from the coal shafts of Greenies Crag, it probably continues, along with the much obscured sandstone outcrops, to the Crag Farmhouse, a little south of the map; near which place (west of Old Hall) it has again, with some show of certainty, been recognised.

No other section of any stratigraphical value is seen until we cross the Tarset Burn and meet the long ascending section of Black Burn. In all essential points the section in that stream, from the limestone well known as the Belling Limestone downwards, is that of the Plashetts group. The Belling and the Piper's Cross Limestones are therefore probably one and the same.

Section in the lower part of Black Burn, Tarset, from the Belling Limestone downward.

	Ft.	In.
Sandstone		
Shale		
LIMESTONE, pale blue, coralline, good; the BELLING LIMESTONE	10 or 12	0
Sandstones and shales, with two or three thin coals - about	400	0
Shale	20	0
LIMESTONE of Gilliehill Clints; brown, with corals and *Productus giganteus*	5	0
Grey Beds or Coarse Shale - about	10	0
Sandstone of Gilliehill Clints	25	0
Shale	35	0
Black Band, like Cannel, with *Spirorbis*, Fish scales, &c.	1	0
Shale	9	0
COAL 0 9 / Band 1 6 / COAL 0 10	3	1
	513	0

The range of the Belling Limestone is marked by quarries and an old limekiln at Belling Rigg, and by an outcrop in Black Burn and swallow holes at several other points in its course. Probably

Digitized by Google

the same limestone comes to the surface in Tarset Burn south from Gatehouse, where a quantity of good limestone was at one time taken out of the bed of the stream. The limestone of Gilliehill Clints may represent the Plashetts Dun Limestone of North Tynedale; its quality however was found on trial to be very inferior. The layer of black band above the coal is seen sticking out here and there in the bank. It may answer to the seam of cannel coal in the section of the Plashetts Coal at Falstone Burnhead.* The coal itself has at various times been worked in Black Burn and near Shipley Shields. The thin band which is so constant a feature in the Plashetts Coal must be supposed to have thickened at the expense of the seam.

If we attempt to trace these strata southwards we are met east from Newbiggen by a change of dip from easterly to southerly, which must bring them down into the Tarset Burn along with the Belling Limestone. It is probable that this limestone passes southwards, under the drifts on the west side of the burn, into the valley of the North Tyne, where there is nothing that so much resembles it as the limestone of Stirks Cleugh opposite Bellingham and those of Wood Park and Black Burn still further south. These limestones, like it, conveniently divide the Carbonaceous Division (of the adjoining district) into an upper and a lower part.† What becomes of the beds northwards is still more uncertain. The Belling and Gilliehill Clints Limestones are last seen near a footway from the Tarset to Black Burn Head. A little group of coals, of which a detailed section has been given on p. 21, is seen at about the horizon of the Plashetts Seam at Midgy Holes a mile above Comb Farmhouse. The uppermost of them—a cannel coal,—crowded with Entomostraca—has been made some use of for the farmhouse fire; burning with much smoky flame.‡

* *See also* section of air shaft near Black Belling, p. 33. At Plashetts there is an impure steam-coal, from 6 to 18 inches in thickness, and from 5 to 20 feet above the main coal, very probably the same. It is not exposed in any open section, but was described by the late manager (Mr. Chapman) as "not a good seam, much mixed with plate partings."

† *See* "The Geology of Bellingham and Wark," Memoir on Quarter-Sheet 106 NE.

‡ While these pages are passing through the press samples of this cannel coal, which is of special interest because of its rarity in the district, have been collected by Mr. Milburn, jun., of Snowhall, Tarset, and submitted to analysis. The analyst, Mr. A. C. Thompson, of Edinburgh, has favoured me with the results of his examination.

Analysis of Parrot Coal (Midgy Holes).

	Per Cent.
Volatile matter	42·8
Fixed Carbon	24·0
Ash	33·3
	100·1

Destructively distilled, at a low temperature (for oil-making), yielded as follows:—

66·7 gallons oil per ton, *sp. gr.* ·898.
13·8 ,, water per ton, containing a little ammonia.
Total nitrogen 1·12 per cent.

Destructively distilled, at a high temperature (for gas-making), it yielded 12·100 cubic feet of gas per ton. Illuminating power and impurities not estimated.

The sample analysed was taken by Mr. Milburn from four different parts of the seam, which he reports at 3¼ feet thick. *See* section on p. 21.

Digitized by Google

About four feet above it is a thin course of limestone with cone-in-cone structure. Thin limestones showing cone-in-cone structure have also been detected on the south side of the High Green fault in the Tarret Burn. Close against the Midgy Holes section there is a fault, probably of considerable throw, and neither the limestones nor the coal are recognised beyond it.

Before passing on to describe those parts of the Carbonaceous Group that undoubtedly overlie the Belling Limestone, it may be well to give some details of the beds of uncertain position lying to the northward of the fault just referred to. Almost all these beds occupy the districts denoted in the map as Highfield Moor, Burngrange Moor, and Emblehope Moor, and are of the usual Carbonaceous type. Their prevalent dip is to the northward. The best of the limestones is that lying in Highfield Burn just on the further side of the fault last mentioned.

Section of Limestone and associated Strata in Highfield Burn.

		Feet.
Sandstone	visible	20
Shale	about	35
Limestone, grey-blue, encrinitic, good, 6 or 7 feet seen		7
Shale, full of calcareous fossils		2 or 3
Shaly Sandstone, with crustacean tracks		
Sandstone with carbonaceous markings and plant-stems: several palatal teeth of fishes (*Psephodus magnus* and *Deltoptychius acutus*)*		

At its exposure nearest the fault this limestone is thrown for 50 or 60 yards into a succession of small step-faults, each depressed to the east. Except for the evidence that connects this fault with a downthrow on the south-east, the limestone might stand for that of the Belling and Piper's Cross. Several other limestones (not to mention the usual impure bands,) are known in Hunter Burn. One of these is indicated by swallow-holes near the Dodd. Another, north of the Dodd, has a section as follows:—

Sandstone.
Shale, about 20 feet, with 6 inches of coal 6 or 8 feet above the limestone.
Limestone, weathering into ochre, 4 or 5 feet visible.

In a scar, a little higher in the stream, near Watch Crag, there is another:—

		Ft.	in.
Shale, 30 or 40 feet, with a pale-green Tuedian-looking band near the top.			
Coal	6 ins. to	0	8
Shale			—
Coal	3 ins. to	0	4
Shale		3	0
Limestone, ochreous, with carbonaceous bits of wood and *Rhynchonella pleurodon*		3	0
Coal		0	5
Shaly and carbonaceous sandstone		3	0
Shale		3	0
Coal		0	10
Shale, 12–15 feet, with limestone bands below.			

* Identified by Dr. Traquair, F.R.S.

Digitized by Google

The best of the coals to be mentioned lies a short way under the Watch Crags. Its actual outcrop is traceable only for a short hundred yards at the head of a streamlet known as the Pit Sike, where it has been worked in levels or "mouth groves" by the shepherds. Its full thickness was measured in the mouth of one of these short levels.

Section of Coal near Watch Crags, Hunter Burn.

	Ft.	In.	Ft.	In.
Sandstone			—	
Shale, carbonaceous, with Coal			—	
Sandstone			3	0
Shale			10	0
Coal	1	2		
Band	0	5	2	5
Coal	0	10		

The levels are crossed by a trouble running apparently E.N.E., which remains so far unproved. About 150 yards to the south the upturning of some shale against a siliceous sandstone band resembling fault-rock and dipping at 45–50 degrees, gives indications of some more serious disturbance. Two miles to the west, at the very border of the map, a coal has been dug out in the south branch of Hunter Burn (Harper Burn) which there is some evidence further west to connect with the Plashetts seam. It is in a disturbed condition owing to the presence of a considerable fault directly on its south side, but the strata associated with it are dipping east. At Watch Crags, and, so far as can be seen, for a mile above it, the beds dip to the west. The country is too obscure, and, wherever it is best known, too much faulted, to permit of more than a surmise as to the relation borne to one another by these two seams.

The only other coal seams in Hunter Barn appear—one in the middle branch (Coal Cleugh) quite at the head, and the other near the foot of Harper Burn, where there are traces of crop pits and coal. The thickness of the seams is in both cases unknown; but some miles to the northward under Reedswood Crag, between Emblehope Moor and Hindhope Law, there is a section deserving more detailed mention. It is capped by the unusually massive grit of the crags.

Section in Reedswood Crag.

		Feet.
Massive Sandstone, rather coarse,	nearly	100
Shale, with Coal and a Limestone,	about	40
Sandstone,	12 or	15

The section of the coal is stated to be—

	Ft.	In.
Coal	1	0
Dirt	0	4
Coal	0	6

Another old level into a different seam, thickness unknown, lies a few feet lower; with an impure limestone some distance under it, making a line of swallow-holes further west. Still further west, beyond a north and south fault of unknown effect, there is

Digitized by Google

said to be an impure 3-feet coal which was worked in one or two shallow pits about the year 1850. The roof was soft "famp" or mouldering shale, and was very bad.

Mention may also be made of several coals, position in the series unknown, lying south of Highfield. One of these lies in Black Linn Burn on the south side of Highfield Plantation. Whatever its thickness (it is said to have been very little) this seam has now been worked out. Another appears in Sidwood Cleugh, and is very doubtfully reported to have been 16 inches thick. Some ironstone balls containing fronds of *Cardiopteris* (*nana*, Eichwald, Sp.) lie about the mouth of this level.

Carbonaceous Division in North Tynedale, continued. Upper Group :—Beds overlying the Piper's Cross and Belling Limestone.— The beds that can be recognised as distinctly higher in the series than this limestone, lie chiefly east of Tarset Burn. In the Falstone district there is a section of about four or five hundred feet of the lowest of these beds above the limestone in Pit Sike,—a small stream entering Hawkhope Burn from the east,—including a coal, said to be 2 or 3 feet thick. At several other places in the same district, between Earls Seat and the Pikes, we have some of the sandstones and shales that directly overlie the limestone. East of the Tarset, the upper group of the Carbonaceous Division is chiefly seen south and west of the Upper Limestone Series, near Rooken Cairn, in or near Black Burn, and in Tarret Burn and Greenhaugh Burn. From what is known of these beds in this and the adjoining Map (106 N.E.) they must at least exceed 1,000 feet in thickness. They consist of a succession of sandstones and shales, calcareous grits, impure limestones, and thin coals, without any very distinctive beds. The character of the strata is best seen in the Greenhaugh and Tarret Burns, and in the streamlets joining Black Burn (near Ridley Shield) from the east. Probably about 600 feet of beds, dipping N.E. and E.N.E. overlie the Belling Limestone on Blackburn Common S.E. from that place, and at least 500 feet underlie the base limestone of the upper series north of Ashy Bog. The beds in these districts, however, are represented at the surface only by sandstone escarpments.

In the Greenhaugh Burn we find three coal seams, respectively, in ascending order, fifteen, twelve, and eighteen inches thick. The lowest of them is underlaid by a small succession of limestones with *Stigmaria*, of a type very characteristic of the group ; the uppermost is overlaid by a limestone more distinctly marine. The general section of the latter is as follows :—

Section near Cleugh Head, in Greenhaugh Burn.

Sandstone, medium grain, passing gradually down to
Shale, coarse, graduating into
Shale, finer, with ironstone nodules and marine shells.
LIMESTONE, impure, but encrinitic, 5 feet.
Shale.
Sandstone.
Shale with an 18-inch coal.

Digitized by Google

In Tarret Burn an 18-inch coal has been worked at a place called Robinson's Groves (*i.e.* levels), a little above the new bridge, —evidently the same seam with the same section of shales and plant-limestone bands below it that is seen in Cat Cleugh, half a mile to the east. The sandstones and shales of the group are seen here and there in Tarret Burn up to the boundary fault of the Upper Limestone Series, near the foot of Sundaysight Cleugh. A coal, three feet thick, chiefly "splint," has been worked south from Gatehouse. So far as can be seen it is lower in the series than any of the strata that appear in Tarret Burn, except, indeed, those near the mouth of the stream. It is cut off upon its west side by a fault running N.W. and S.E., which is seen at a foot bridge near Tarret Burnmouth. Bore-holes put down beside Burnmouth and the Tarset Burn failed to recover it. The position of this coal a few hundred feet above the Belling Limestone is similar to that borne to the Piper's Cross Limestone by the two or three feet coal in Pit Sike, Hawkhope Burn, mentioned on last page.

The remaining coal seams that call for mention lie north of Ridley Shield. A 1-foot coal, much hitched and spoiled, appears in the stream close by the house, probably beside an east and west fault. Another seam, thickness not now known, lies higher in the group, above a small waterfall at the foot of the side streams (Shield Sike and another) entering from the east. Further up in one of these streams, and said to be cut off on the south by a fault, is a coal with section as follows :—

Section of Three-feet Coal in Shield Sike, Black Burn.

	Ft.	in.
Sandstone, calcareous, 8-feet seen - - -	8	0
Shale, with 8 inches of coal about 6 feet above the main seam - - - -	8 or 10	0
Coal, partly seen 2 ft. 6 in. thick, in open level -	3	0
Shale - - - - -	10 or 15	0
Coal - - - - - -	0	6

A 2-feet seam, very probably the same, has been worked in the main stream higher up, and also a 9-inch seam, 25 or 30 feet below it. Another 2 or 3 feet coal has been worked almost at the threshold of the house at Blackburn Head. Towards the outlier of the Upper Limestone Series near the Rooken and near the head of Black Burn, one other coal has been dug out at the surface. It lies directly between two beds of sandstone—

Sandstone, 8 feet seen.
Coal, 10 inches.
Sandstone.

Passing to the south-eastward we find the beds of the Carbonaceous Division continuing along the southern border of this Map over into the lower part of Redesdale. West of the site of Hareshaw Dam, now drained, we note, in passing, a limestone of fair quality, containing encrinites and a trilobite, *Phillipsia seminifera*, Phil. It may probably occupy a similar position high in the

Digitized by Google

series as another bed of limestone, 6 feet thick, lying out on the moor east of the Rede,* and another containing corals already referred to at Dyke Head near High Rochester.

The general section on the east side of the Rede above East Woodburn is an ascending series from the river up into the Fells, with a scarcely perceptible dip (averaging one degree) to the eastward. Not less, probably, than 700 feet of the Carbonaceous Division occupy this ascent across Darney Crag to the base limestone of the upper series in Hartside. The only section which need be given in detail in this part of Redesdale is a section of coal and impure limestone in the river near the Old Rede Bridge. This limestone is almost a calcareous grit.

Section in the Rede, near the Old Bridge.

	Ft.	in.
Calcareous grit, or very impure limestone, visible - - - - -	5	0
Shale, with thin bands of limestone and calcareous grit; with *Rhynchonella pleurodon*, small *Producti*, great numbers of *Chætetes*, &c. -	8	0
Coal, - - - 15 inches to	1	6
Sandstone, thick - - - - -		

The coal is worked in the east bank. These fossiliferous beds yielded a specimen of *Lepidodiscus Lebouri* (Sladen),† a new species of this rare Cystidean genus. The massive sandstone at the bottom of the section, visible for half a mile down stream, is the lowest bed known in this part of Redesdale, lying fully 700 feet below the Redesdale Limestone. The calcareous grit re-appears above the sandstone but without the coal at Park Cottage, just out of the Map, and against a small fault. A double coal seam may be mentioned as occurring under the sandstone of the Heugh, a crag overlooking the old bridge referred to. The section is —

	Feet.
Sandstone (the Heugh) rather fine-grained, about -	20
Shale with Coal { Coal 7 inches / Band 2 feet / Coal 7 inches } about - -	25

An impure greenish limestone of the kind characteristic of the Carbonaceous Division, and containing *Rhynchonella pleurodon* and bits of wood, lies a little higher in the series in the Black Burn.

* Under The Dod, west of Hartside.

† *Quart. Journ. Geol. Soc.*, vol. xxxv., p. 744; 1879.

Digitized by Google

CHAPTER V.—CARBONIFEROUS LIMESTONE SERIES—*continued.*

The Upper Limestone Series.

Calcareous Division.

The Upper Limestone Series consists of Limestone beds of distinctly marine origin alternating with carbonaceous-grey shales and pale yellow sandstones with thin coals, and with ironstone nodules in some of the shales. The alternations of these beds fall into a certain orderly sequence that marks them out into zones and cycles, the completeness of which distinguishes this series extremely well from the strata of the Carbonaceous Series. This *cyclical* arrangement can best be illustrated by a typical section giving the details of several of the zones. It is taken from Elsdon Burn, between Dunshield and Elsdon Mill, and is given as usual in descending order.

Section in Elsdon Burn, between Dunshield and Elsdon Mill.

		Ft.	In.
Calcareous Division.	Shale, with marine remains in lower part -		
	Limestone, encrinital, 6 feet seen -	8	0
	Clay with 1 inch of Coal - -		
	Sandstone with *Stigmaria* in upper part -	32	0
	Shale, with marine remains in lower part -		
	Limestone, inferior - - -	9	0
	Fireclay, obscure - - - -		
	Sandstone, containing rootlets of *Stigmaria* in its upper part - - -	15	0
	Shale - - - - -		
	Limestone, with *Productus giganteus* -	1	6
	Shale, carbonaceous - - -		
	Sandstone with worm ? tracks - -	62	0
	Shale - - - - -		
	Limestone, dun-coloured, impure -	3	6
	Sandstones and Shales, with carbonaceous matter, obscure - - -	50	0
	Coal, Elsdon and Fourlaws Seam -	3	0
	Sandstones and Shales (not seen) -		
	Sandstone - - -	55	0
	Shale, with some marine remains and ironstone nodules in lower part -		
	Limestone; Fourlaws Limestone -	12	0
	Sandstone, 50 feet seen - -		
	Obscure (containing shale with marine remains and ironstone nodules) -	100	(approx.)
	Limestone; Redesdale Limestone -	15	0
Carbonaceous Division.	Obscure, usually sandstone with worm tracks passing down into shale with some plant remains - - -		
	Shale, with Ironstone nodules; Redesdale Ironstone Bed - -		
	Obscure, probably with a thin Coal -		
	Sandstone and Shale - - -	49	0
	Limestone, impure, with rootlets of *Stigmaria* - - - - -		
	Shale - - - - -		
	Coal, 1 foot - - - -		
	Strata, chiefly shale, with calcareous bands containing *Stigmaria* - -		

Digitized by Google

The interval between any one limestone and the next in order above it is thus indicated as forming, in the Calcareous Division, a complete cycle of deposition, of which the lower part is marine and calcareous, and passes up into mechanical sediment in a fine state of division; while the upper part is marked by a coarsening of the deposits, by an intermingling of plant remains, and by the presence (generally), near the top, of Coal or the roots of *Stigmaria* in situ, indicative of shallowed water and the borders of the land. The formation of the Upper Limestone Series was marked by sudden successive strides of depression bringing in colonies of marine life from an outlying ocean, upon each of which there gradually supervened a silting up of the sea-bottom and the growth of a dense, if not very varied flora. It will not escape the attentive reader of the section that the strata of the Carbonaceous Division, at the bottom, are at once distinguished by an intermingling of conditions. In the upper Limestone Series, so far south at least as this, there is no such thing as a limestone containing *Stigmaria*.

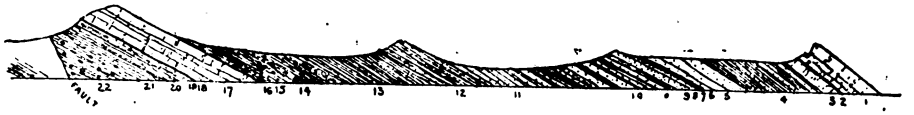
The cyclical order of superposition can best be seen, within the area of this Map, in the strata at the foot of Dargues Burn in Redesdale; in Elsdon Burn, along the line of the section just given; and in Penchford Burn near Grasslees. But nowhere can the characteristic features of the Upper Limestone Series be more easily seen and studied than in the section of one complete cycle of strata represented in Fig. 3.

FIG. 3.

*Section at Elsdon Mill.**

(Scale 1 inch to 48 feet.)

S. N.



Section at Elsdon Mill.

		Ft.	In.
1.	LIMESTONE, encrinitic - - - - -	6	0
2.	COALY - - - - - -	3	0
3.	Underclay - - - - - -		
4.	Sandstone and shale - - - - -	12	0
5.	Sandstone - - - - - -	6	0
6.	Shale - - - - - - -	0	6
7.	COAL - - - - - - -	0	3
8.	Underclay - - - - - -	0	9
9.	Sandstone, penetrated by *Stigmaria* rootlets - -	1	6
10.	Sandstone with shaly partings - - - -	12	0
11.	Sandstone, in thin courses - - - -	10	0
12.	Sandstone, laminated, with scattered plant remains -	6	0

* We owe this admirable section, which can be seen in all its essential details beside the cart-track from the main road down to the Mill, to the interest taken in such matters by Mr. Elliot, the miller, who has opened it out with his own hands on purpose to see the beds.

Digitized by Google

	FT.	IN.
13. Shale, with shreds of vegetable matter - -	10	0
14. Shale with marine fossils and a few ironstone nodules, about - - - - - -	8	0
15. LIMESTONE, thin course of - - - - }	2	0
16. Calcareous shelly shale - - - - }		
17. LIMESTONE, *Lithostrotion*, in the attitude of growth in upper part; *Productus giganteaus* near the bottom -	8	0
18. COALY - - - - - - -	0	1
19. Underclay - - - - - -	1	0
20. Sandstone and shale, carbonaceous impressions -	3	0
21. Shale, coarse and with plant impressions - - }	18	0
22. Shale, finer, with marine fossils and ironstone nodules }		
Fault.		
23. Shale of a different quality with a band of *Stigmaria* Limestone. *Carbonaceous Group.*		

The ironstone of the Calcareous series occurs in the form of nodules, and is limited almost entirely to the lower or calcareous part of the shales. The Redesdale Ironstone Bed differs from the others only in not being based upon limestone.

The strata of this upper group enter the map from the south on the east side of the Rede. Between Hartside and the extreme south-eastern corner of the Map there is an (on the whole) ascending section of these beds, probably the thickest that is to be found within it. By means of faultings and undulations the beds are then spread far out to the westwards and northwards. They thus come to occupy a large area, rendered extremely irregular by the number of faults that intersect it, extending westwards to beyond High Green on the Tarret Burn, north-westwards nearly to Rochester upon the Rede, and northwards to within a mile of the Wilkwood Burn. The base of the group, and the underlying Carbonaceous Beds, appear within this area several times over.

The bottom limestones of the group are fortunately well marked and constant. The section of this part of the series has already been incidentally given (p. 42). The Redesdale and Fourlaws Limestones, with the Redesdale Ironstone Bed below the former, and the Fourlaws Coal (known under different names at Raylees, Elsdon, Soppit, Girsonsfield, Penchford, Wilkwood, Brownrigg, High Green, and Hareshawhead,) some distance above the latter, form a group stratigraphically quite invaluable. Except for the unusually distinctive characters of these beds in fact, the stratigraphy of the whole northern part of the Map must have remained in confusion. The higher limestones of the series are more like repetitions of similar beds, and vary more from place to place.

Before passing on to describe these strata in detail it may be remarked that the Upper Limestone Series, like the Carbonaceous Group, gives indications of a gradual change of conditions towards the northwards. The limestones show signs of a certain amount of subdivision or multiplication, attended in some cases with a deterioration in their quality. In the southern part of the district they are invariably blue, blueish grey, or cream coloured, but in the north they are occasionally parti-coloured or concretionary,

Digitized by Google

or weather with a hard ferruginous crust. In one case a limestone rests upon a few feet of greenish and clayey Tuedian-looking shale, with purple patches, and the same limestone is almost directly covered by greenish calcareous bands. In another case a massive limestone is covered at once by sandstone without the usual upward graduation through shale. All these are hints of conditions unknown towards the south.

The beds can best be described in small districts partly topographical, partly geological. We begin at Hareshawhead west of the Rede.

Hareshawhead District.—The district first to be described is bounded on the north and south by faults. The fault on the south brings up the sandstones of the Carbonaceous Division at the border of the Map (in Callerhues Crag); the fault on the north —a fault extending westwards from Ottercaps to Sundaysight,— brings down higher beds of the Limestone Series. On the side next the valley of the Rede a north-and-south fault is inferred from the rapid dip of the beds towards the strata of the lower series in the river; and in the west, the boundary is partly the continuation of a well-recognised fault and partly an obscure outcrop.

The strata exposed in the 3 or 4 square miles of ground thus limited do not much exceed 300 feet in thickness. The beds that have been mapped are the two base-limestones of the group and the Fourlaws Coal. The characteristics of these beds can best be shown in a general section:—

General Section in the Hareshawhead District.

Sandstones and Shales.
COAL; HARESHAW HEAD and FOURLAWS SEAM, 3 ft. 6 in.
Sandstone and Shales.
Sandstone.
Shale, almost unfossiliferous; a few marine fossils and ironstone nodules near the bottom.
LIMESTONE, encrinitic, not coralline; FOURLAWS LIMESTONE.
Sandstone and Shales.
Sandstone.
Shale, rich in marine fossils and ironstone nodules.
LIMESTONE, coralline; REDESDALE LIMESTONE.
Sandstone.
Shale, with marine fossils and ironstone nodules; REDESDALE IRONSTONE BED.

The Redesdale Limestone, the bottom limestone of the series, appears at Cross Law and again on the south side of Corsenside Common. It is best seen, with some of its overlying shale and sandstone (the latter of which caps the ground in a straight line between these two outcrops,) at some old kiln-quarries on the Woodburn Road. The Redesdale Ironstone Bed is not visible. Cross Law forms the summit of a dome in the strata. The outcrops and their relation to this anticline can be seen in a bird's eye view from the Otterburn Road. The Fourlaws Limestone appears on Corsenside Common shelving off the anticline on

Digitized by Google

two of its sides, towards the east and west. This limestone is better seen (on the south side of a fault which will be mentioned directly) at the Hareshaw Kiln, where it is quarried under its shale, and has been found to rest on thill. The Hareshaw Head coal has been worked in two distinct areas separated by the fault referred to. It was first worked in 1848 by the Hareshaw Iron Company about 150 yards south of the Hareshaw Kiln. The section of the pit, 17½ fathoms deep, is as follows. It is given as it occurs in the note-books of the late Mr. T. J. TAYLOR.

Section of Percy Pit, Hareshaw Head.

	Ft.	In.
Moss and Clay	6	2
Freestone	15	5
Blue Metal	4	0
Grey Metal	2	10
COAL	0	5
Grey Metal	0	9
Freestone	9	3
Grey Metal	0	9
Post Girdle	0	6
Grey Metal	6	0
Post Girdle	1	8
Grey Metal	5	4
Freestone	9	6
Grey Beds	5	6
Freestone	13	2
COAL	0	7
Grey Metal	2	8
Grey Beds	0	4
Grey Metal	3	0
COAL	0	3½
Blackstone, with COAL	0	4½
COAL	2	10
HARESHAW HEAD SEAM	3	6
Grey Metal and Blue Metal	6	0
COAL	0	5
Freestone and Plate	3	8
	105	1

In Hazel Cleugh, some distance to the southwards, the spring known as the Bore Well marks the site of a trial bore-hole into the sandstones and calcareous grits of the Carbonaceous Division, and the approximate position of the fault which brings them in towards Callerhues Crag. The other area occupied by the Hareshaw Head Coal in the district is denoted by a number of old workings at a lower level further north. The southern limit of the pits roughly outlines the position of the fault that divides this little coal field, against which some of them have been worked. The coal, 32 inches thick, "splint" in its upper part and with a 2-inch band, is at present worked by level near the Bellingham Road. W.N.W. from Hareshaw Head the old workings continue for about 600 yards. The coal is known by bore holes for about 300 yards further.* The fault bounding

* For these borings see Appendix, p. 134. I wish to express obligations to MR. ARMSTRONG, of the Hareshaw Head Pits, for his willing assistance.

Digitized by Google

the district on the north is supposed to cross near a group of copious springs known as the Nine Well Eyes.

District of Sundaysight and Highgreen, and of the Padon Hills, south of Gib Shield.—The exact relation of this district to that of Hareshawhead is not very clear. The more westerly position here occupied by the same beds seems in the main to be the result of the large east-and-west fault, just referred to, that extends from Ottercaps to Sundaysight. This fault produces much mechanical disturbance in the limestone near Sundaysight farm-house, and a complete stratigraphical break in the Tarret Burn. The boundaries of the district now described are: southwards, this fault; westwards, partly its presumed continuation, with the Carbonaceous Division on its further side, and partly an outcrop of the bottom limestone in the Dodd Hills towards the north; northwards, the line of hollow and fault that lies between Padon Hill and Gib Shield; and eastwards, an ill-defined line beyond which the beds cease to be traceable.

The chief section of the district is in all essential respects identical with that of the typical district of Redesdale and Fourlaws, six or seven miles to the south-east.* It is taken through Black Crag (901 feet), about a mile S.S.E. from High Green; the details are filled in from the sections in the Tarret, Sundaysight, and Hollinhead Burns.

Section in an E.S.E. W.N.W. direction from Black Crag through the foot of Hollinhead Burn.

	Ft.	In.
Shale with ironstone nodules		
Limestone, massive	10	0
Fine sandstones with shales Sandstone, thick, coarse, and massive in parts (= Aid Crag, Hepple Heugh, &c., in the Redesdale district). Shale	350	0
Limestone	8	0
Sandstone, with *Stigmaria* near the top Sandstones and shales	70	0
Limestone imperfectly seen, say	8	0
Sandstone and Shales, not less than	200	0
Coal, Highgreen, and Fourlaws Seam, 2 ft. 2 in. to	2	6
Sandstones and Shales Shale, few fossils or ironstone nodules	120	0
Limestone, encrinitic; Fourlaws Limestone, 10 ft. or	12	0
Stigmaria Bed and thin Coal Sandstones and Shales Shale, with marine fossils and ironstone nodules — 150 ft. to 200 ft.	175	0
Limestone, with shale bands intercalated in upper part; Redesdale Limestone	15	0
Sandstone and non-nodular shale — 10 ft. or	15	0
Shale with ironstone nodules and marine fossils; Redesdale Ironstone Bed	25	0
Thin Coal and fireclay		

The position of these limestones on the upland ground is indicated by swallow-holes. A section of the two uppermost of them, with that of the massive Black Crag sandstone (the same

* This will be described in the Memoir on the Geology of Bellingham and Wark. Mem. Geological Survey, Quarter-sheet 106 N.E. See also the sections on p. 53.

Digitized by Google

sandstone known further south as the Carrycoats or Aid Crag Grit), is fully seen in the Tarret Burn east of Smiddywell Rigg. The Fourlaws Coal is worked for household use in Hollinhead Burn, in a pit 7½ fathoms deep. Many disused workings honeycomb the bank of the stream. The Fourlaws Limestone appears lower down; the Redesdale Limestone is visible in Sundaysight Burn, and in the Tarret Burn further up.

On the south-west side of Black Crag a large fault reverses the dip from E.S.E. to W., and brings the highest beds of this section against strata having a position above the Fourlaws Limestone.

In Sundaysight Cleugh, the ravine north of Sundaysight, the Redesdale and Fourlaws Limestones and the Redesdale Ironstone Bed are met twice over between the foot of the stream and the Sundaysight road. Their dip is at about 40 degrees. The nodules of the Ironstone Bed are small and worthless. The main sandstone between the limestones is partly coloured a warm red. The general section is as given above.*

To the north of these beds there is a complication of faults, the chief result of which is to repeat the bottom limestones and the coal twice over in that direction; first, in the Tarret Burn beyond the Highgreen Basalt dyke, and again north-east from Pit Houses. The first of these dislocations crosses Tarret Burn almost beside the dyke. The section from the Fourlaws Coal down to the base of the series is seen in good descending order as we pass up stream. The coal can be seen lying under a projecting ledge of sandstone on the left hand, thus :—

	Feet.
Massive Sandstone - - - -	-
Shale - - - - -	- 1
Coal - - - - -	- 3½

The detailed section of the coal at this point may be given as reported by Mr. M. Robson of Falstone, who formerly worked it:—

Swad (impure coal), not used.
Splint Coal.
Free Coal.

The Fourlaws Limestone is in a ferruginous condition, a condition which it is more than once found to assume in the Fourlaws district itself, where it was at one time put into the furnace along with the ironstone. The Redesdale Limestone, with the underlying section admirably displayed, strikes along Smithy Cleugh. This section must be given in detail :—

Section below the Redesdale Limestone, Smithy Cleugh, Tarret Burn.

	Feet.
Limestone, containing corals - - - - -	
Some Coal and Fireclay - - - - - -	
Sandstone - - - - - - - -	10 to 12
Shale, coarse, with a few plant remains - - -	2 to 3
Shale, with small ironstone nodules, and full of marine fossils - - - - - - - -	30
Coal - - - - - - - -	1

* About 45 feet above the Redesdale Limestone, however, there is a band of limestone 1½ feet thick, not elsewhere met with.

Digitized by Google

The two faults referred to, complicated by another of opposite throw lying between them, pass the head of this small stream. As an effect of this middle fault, the Redesdale and Fourlaws Limestones are seen almost in apposition. The latter has been worked in a large quarry and burnt for lime; the former has been unsuccessfully mined for lead ore a few yards to the W.N.W. of the quarry. The coal (the Fourlaws Coal) has been worked at one time both to the east and west of it. In passing eastwards beyond this point the three faults seem to simplify one another, or to disappear. The northernmost of these faults was well recognised in coal pits a little north of the quarry; it rendered the coal for some distance sparry and unfit for sale. The effect of this large fault is a downthrow of the strata to the extent of about 400 feet on its north side; the coal-pits referred to are thus in the Fourlaws Coal. It has been worked (probably worked *out*) in pits dotting the slopes all the way across to the Tarret Burn. The dip remains southerly, and the underlying limestones emerge on the moor beyond the parish boundary, marked by swallow-holes. They extend eastwards half way towards Troughend, and are then lost against a basalt dyke and probably amongst faults.

Another large downthrow fault, strongly marked on the moor between the parish boundary and the Tarret Burn by a discordance in the strata, now brings in once more the higher limestone that two miles to the south overlies Black Crag, together with one limestone yet higher. The representative of that massy crag itself is the powerful sandstone escarpment that dominates the east side of the Tarret Valley below Gib Shield. The limestones, as is usual on the moors, are represented by swallow-holes and by very occasional exposures. The Fourlaws Coal must lie hid on the west side of the Tarret Burn, which is a long drift-covered slope. It can scarcely be doubted that a limestone outcrop in the Great Dodd, a mile out towards the west, represents the Redesdale Limestone.

These strata strike north, and are abruptly truncated against the sandstone outcrops rising above Gib Shield. An impure coal and thin limestone of the Carbonaceous Series is brought into the valley, not without some disturbance, a little south of that house. The line of hollow passing east into Redesdale is the line of fault.

District of Brownrigg and Rattenraw.—This triangular district, bounded on the south by the Dargues Burn, on the N.E. by the Rede, and on the W. by an obscure outcrop of the base limestone, is of some little importance as supplying Redesdale up to the present date with most of its coal. From the relation borne by the Brownrigg Coal Seam in Blakehope Fell to the overlying and underlying beds, there can be no doubt whatever that it represents the coal of Fourlaws, Hareshawhead, and Highgreen. A row of swallow-holes W.N.W. from Dargues Hope marks the outcrop of one of the base-limestones, probably the Redesdale Limestone. The limestone in the stream at Rattenraw, although richer in corals

Digitized by Google

than usual, is without doubt the Fourlaws Limestone, and the two well-exposed limestones near the foot of Dargues Burn are probably the first limestones above the coal. This little section in Dargues Burn very well displays the sequence of strata characteristic of the Upper Limestone Series. The highest of the two limestones, 7 feet thick, has a coal, 10 inches thick, a short distance below it, and contains *Productus giganteus* and (?) the large foraminifer *Saccamina Carteri*. The other is covered by shale containing fossils and ironstone nodules. The Brownrigg Coal has been worked on Blakehope Fell for more than a century. It was first worked on the north side of a fault with a northerly downthrow exceeding 20 fathoms, (as judged from the reputed depth of the shafts on its two sides); of late years it has been worked only on the south side. Ratten Row Common, beyond the boundary wall of Blakehope Fell, is a disputed royalty and has not been entered by the workings, but the coal comes to an outcrop, which can be seen, in Ratten Row Burn. Westward and northward from this stream the beds are very much obscured. The coal, two feet thick, is "splint" in its upper part. It is not divided by any band; its quality as a house coal is excellent, though rather ashy. The following is its section as worked in 1879 on the south side of the fault:—

	Ft.	in.
Splint Coal	0	8
Free Coal	1	4

In 1856 they were working the coal on the north side of the fault. The following section is taken from the "Account of the Strata of Northumberland," &c., published by the North of England Institute of Mining Engineers.

Section of Temple's Working Pit on Elishaw Common (Blakehope Fell, April 17, 1856).

	Ft.	in.	Ft.	in.
Clay and Soil			62	0
Metal			1	0
Mixed stone			3	0
Marl			0	5
Red Freestone (? brown)			6	0
Freestone, plate, and grey beds			3	0
Metal			2	0
Coal, top	0	1		
Blackstone	0	11		
Coal, splint	0	5	3	2
Coal, free	1	9		
			80	7

The exact position of this pit is not known.

District of Bennettsfield, Yatesfield, and Ballyardley Hill.—Following the coal to the other side of the River Rede we enter extremely obscure ground. The Brownrigg Coal has been worked at Bennettsfield, but there was a fault passing close to the pits on their S.W. side—perhaps the same fault, with a downthrow to

Digitized by Google

the north, that is seen with one of the base limestones leaning against it at Bagraw Bridge. The coal was unsatisfactory. Shafts were also sunk by the roadside half-way between Bennettsfield and Elishaw, but at that point also a fault is said to have passed close beside the workings, and the coal was reduced to 20 or 22 inches and very bad in quality. An 18 or 20-inch coal in Durtrees Burn, below Yatesfield, is said to have been the same seam,—"splint," as usual, in its upper part. The limestone outcrops near Yatesfield and Ballyardley Hill are probably the base limestones of the series, but no certain identification of them is possible.

District of Troughend, Tofts, and Garret Shield.—In this district is included all that portion of the Upper Limestone Series west of the river Rede which has not yet been described; except the outliers at the Rooken. A large part of this ground is moory and drift-covered, with the limestones here and there lying in the streams,—swallow-holes indicating them here and there on the moors. There is a good deal of faulting and bending in the strata, but the prevalent dip is easterly, and the beds are all probably higher in the series than the coal of Hareshawhead and Highgreen. A limestone crossing under a peat moss on the west side of Deer Play contains *Saccammina.* One of the strong sandstones between Seven Pikes and Lord's Shaw probably represents the sandstone of Black Crag in the Sundaysight district and the Aid Crag grit near Ridsdale, and is thus some hundred feet above the coal. The limestones, which are all of fair quality, are best seen,—both the beds and the undulations which affect them, in Tofts Burn. These Upper Limestone strata appear to be brought obscurely on the east against the subjacent Carbonaceous Division. A limestone differing from all those as yet known in the Limestone Series appears near the foot of the Tofts Burn, and may lie on the further side of the presumed fault. The section of this singular limestone has not yet been given and may appear here:—

Section at the foot of Tofts Burn, near the Watling Street.

	Feet.
Sandstone, ripple marked	
Shale	
Limestone, with *Leperditia* and rootlets of *Stigmaria* in upper part; encrinitic in lower	3 to 4
Shale, full of corals (? *Lithostrotion junceum*); some crinoid ossicles; *Productus punctatus*	3 to 4
Limestone, with *Productus giganteus, Lithostrotion irregulare, L. junceum, L. m'coyanum, Clisiophyllum,* sp., *Aviculopecten cælatus, Euomphalus,* sp., *Terebratula,* sp.	6
Rubbly Sandstone, with *Stigmaria*	

These strata are in a somewhat disturbed condition.

Outliers near the Rooken Cairn.—A few miles out to the W.N.W. a northerly dip in the strata brings the Upper Limestone

Digitized by Google

Series back again in two outliers. The limestone formerly worked at the Rooken Kilns, first by quarry and then by level, is without much doubt the Redesdale Limestone. It is again visible at Drypit Knowe, a mile further west. The Fourlaws Limestone appears in Limestone Knowe, near the large fault which bounds both of these outliers upon the north.* The same fault extends eastward across the Rooken Burn with considerable fracture of the strata there. At the head of this stream, and above both the limestones, are the old workings of the Rooken Coal. The Fourlaws Limestone, 8 or 9 feet thick, was passed through, with a shale and some ironstone nodules above it, in the water level. Signs of the Redesdale Limestone can be detected in the streamlet. The Rooken coal, like the High Green Seam, consisted of a "splint" coal and a "free" coal, and was 3 to 3½ feet thick. It was cut off towards the dip by a fault, which passing obliquely towards its outcrop terminated its strike in its westerly direction. Towards the east it was lost with equal suddenness; and beyond the road passing into Redesdale, borings in various places failed to find any sign of the coal. This outlier therefore probably lies within a triangle of faults.

District of Wishaw, Raechester, Ottercops, Raylees, Monkridge, and Todholes.—Returning now to the southern border of the map we take as one district that portion of the Upper Limestone Series lying east of the Rede and south of the Elsdon and Whiskershield Burns, or, geologically speaking, south of a fault which traverses the east-and-west valley which these streams occupy. In its southern part the district is bounded by the limestone under the summit of Hartside Cairn (Trigonometrical Station 1,097 feet above the sea), the highest step in the fine succession of escarpments that rise, point beyond point, and with an easterly dip, from the Rede into East Woodburn Common. The ascending section from this limestone to beyond Wishaw Pike is essentially that of the Redesdale and Highgreen districts. The Fourlaws Coal is not known, but it has not been sought for. The other strata have the usual character and the characteristic grouping—the Redesdale and Fourlaws Limestones at the base and about 100 feet apart—a wider interval above them, occupied by minor sandstone outcrops, and (probably) the Fourlaws Coal—two limestones, close together, above this interval and near the foot of a thick and prominent sandstone (Wishaw Pike)—and then, above the sandstone, three limestones pretty close together. These beds have an easy dip, beginning on the west at 1 or 2 degrees, and gradually increasing to 5. Their correlation with the districts of Redesdale and Highgreen can best be illustrated by a table.

* The owners of the Rooken kiln, their supply of limestone failing them there, made trial of a limestone of the Carbonaceous Division in the Wind Burn north of this fault. They found it to be of a different and unsatisfactory nature.

Digitized by Google

Redesdale District.

(Sheet 106 N.E.)

	Ft.	In.
Zones of the Upper Limestone Series		
Limestone, pale, weathering knotty	7	0
Sandstone, prominent, massive, coarse in upper part (Aid Crag, Hepple Heugh, Coldlaw); and shales	200	0
Limestone	8	0
Sandstone, *Stigmaria* at top: low crop; some shales	60	0
Limestone	8	0
Sandstones and Shales, about	150	0
Fourlaws Coal, 2 ft. 6 in. to 2 ft. 8 in.	2	7
Sandstones and Shales	100	0
Fourlaws Limestone, encrinitic; shale above it nearly unfossilliferous	13	0
Sandstones and Shales	120	0
Redesdale Limestone, coralline; fossilliferous shale above it: Ironstone Bed 15 feet below it, based on thin coal	16	0
Thick Sandstone, based on the *Carbonaceous Beds*		

Highgreen District.

(Sheet 108 S.E.)

	Ft.	In.
Zones of the Upper Limestone Series		
Limestone, encrinitic, dark grey	10	0
Sandstone, prominent, very massive, and coarse in parts (Black Crag)	350	0
Limestone	8	0
Sandstone, &c., *Stigmaria* at top	70	0
Limestone	8	0
Sandstones and Shales	200	0
High Green Coal, 2 ft. 2 in. to 3 ft. 6 in.	3	0
Sandstone and Shales	120	0
Limestone, encrinitic; shale above it nearly unfossilliferous	12	0
Sandstones and Shales	175	0
Limestone, coralline; fossilliferous shale above it: Ironstone Bed 15 feet below it, based on 1 foot coal	15	0
Carbonaceous Beds (faulted up).		

East Woodburn Common.

(Sheet 108 S.E.)

	Ft.	In.
Zones of the Upper Limestones Series		
Limestone, pale, knotty magnesian grey, about	8	0
Sandstone, prominent, gritty, and felspathic in part: (Wishaw Pike, Hunterlee Hill)	185	0
Limestone - say 7 or	8	0
Sandstone, low crop, space for shales	50	0
Limestone - 12 or	14	0
Low Sandstone outcrops: coal not yet known, but worked (2 ft. thick) 1½ mile to the north - about	120	0
Limestone; shale not seen	12	0
Sandstones, &c.	90	0
Limestone; shales not seen about	15	0
Thick Sandstone, with one fairly good limestone, and the *Carbonaceous Beds*, below it		

The Limestones under and above Wishaw Pike are seen in the stream at Wishaw. The whole group passes southward against a powerful fault throwing the beds 600 or 700 feet down upon its further side.

Digitized by Google

Another important displacement lies directly to the northward. On the further side of this fault, which, though not conspicuous on the ground, has well marked stratigraphical effects both here and far to the westward, the same succession of beds is found again. The displacement has depressed them 200 or 250 feet to the north, in which direction they begin to assume an easterly strike. The missing coal, 2 feet thick, has been worked in a range of pits situated high on the bank south of Raylees Burn. The sandstone of Wishaw Pike is quarried in Hunterlee Hill (Trigonometrical Station 1054 ft.). Three limestones closely grouped together above this sandstone can be traced as far E.N.E. as the Steng Cross. The section of the bottom limestones is quite clearly seen in Raven's Cleugh, as follows:—

Section of the Bottom Limestones in Raven's Cleugh.

	Ft.	In.
Strata, containing the Fourlaws Coal, 2 ft. thick		
Massive felspathic Sandstone		
Shale		
Limestone, encrinitic	12	0
Sandstone with *Stigmaria*	94	0
Strata		
Limestone, with intercalations of shale at top (as in Redesdale District) 9 ft. of it seen, say	15	0
Sandstone, 2 or 3 feet	30 or 40	0
Shale, coarse, no ironstone nodules, 12 feet		
Shale, with small ironstone nodules, 12 feet seen		
Strata, containing a small Coal seam		
Thick Sandstone		

The Redesdale Ironstone Bed here, as further west, is probably worthless. The workings into the Fourlaws Coal lie further to the west and are not carried as far as this stream. They are for the present disused. In the old levels, beyond the sandstone boulder known as the Grey Mare, the coal was still visible in 1877 with its full thickness of 2 feet. Towards Weather Hill its outcrop is again quite obscure. In Birky Gill the Fourlaws Coal is once more known, being recognised as such by the pitmen. Its thickness there varies from 29 to 36 inches. The beds are dipping at a varying angle (12 to 28 degrees) to the W.N.W. The old pits extend beyond the road from Woodburn to Otterburn. The workings were crossed by a "trouble" about 100 yards on the south side of the Gill, and a shaft was sunk 8 fathoms without recovering the seam. A trial level by the river side, a little further to the south, met with no better success.*

The higher limestones and associated beds in the eastern part of the district now described (Raechester, Ottercops, Harwood Head, &c.), are known chiefly in discontinuous outcrops. In the extreme south-eastern corner they dip south of east but decidedly in a crushed condition, especially beyond the Edinburgh road. North from the Ottercops Burn they have a fairly steady dip straight east, resuming their south-easterly dip further north.

* I was indebted to the late Mr. Baty, of Sarelaw, Redesdale, for information respecting this and the High Green Coal Seams.

Digitized by Google

An anticlinal fold extends into this ground in an E.N.E. direction from the Redesdale district. It is the same anticlinal fold that for a considerable distance to the south-westwards has separated between a series of regular strata (on its south side) and a series spreading far out in broken undulations, to which belong in fact those of this Map. It is this partial fold also that causes the bending of the beds into a northerly dip at Wishaw, and into a dip north of east at Wolf Crag (Trigonometrical Station 918 ft.) near the Edinburgh road, besides much obscure undulation and crushing of the strata, especially in the ground round Whaup Moss and from there east to Wolf Crag and north to the Ottercops Burn. Among the upper limestones in this Map there is unfortunately no distinction of mineral character, nor (so far as is yet known) of fossil contents, which is at all sufficient of itself to identify the same limestone at different places. It may be especially remarked respecting their *colour*, which varies from a pale blue to a pale dun, and might seem to offer one distinctive character, that about half a mile east from Whaup Moss one of the limestones may be seen passing within a few yards from the strongest shade of blue to the palest variety of dun. It is this limestone apparently that spreads over such an unusual extent of hummocky ground in the Leehouse and Comb Riggs; appearing in green-vested knolls that rise through the heather, and dipping unevenly to the east. On both sides of the Ottercops fault, before referred to, there are at least six or seven limestones between the Fourlaws Coal and a grit of rather coarse and occasionally pebbly texture, faulted (apparently) from Ray Crag on Kirkwhelpington Common (south of the Map) to Long Crag just within it, and continuing north-east into Wolf Crag. This is probably the same strong bed of grit, which from its persistence throughout the whole of the Map to the south (106 N.E.) has been locally designated as the *persistent grit*.* Beyond the Ottercops Burn it may be the same grit that is seen at Birky Burn; if so it is recognised no further on. There is a small group of four impure limestones seen in Raechester Burn west of the highway. These have all been developed above the "persistent grit" in passing north-east a distance of 10 miles from the North Tyne.

Searches for coal were made in the last century near Ottercops. They met with no success, but the deepest of the borings may be given here. Three others will be found in the Appendix.

Account of the Boring at Ottercops, about 400 yards to the East from the House,† August 23, 1759.

	Ft.	In.
Soyl and stony clay	6	0
Soft blue mettle	13	6
Blue mettle stone with water	3	0
Coale	0	2

* *See* Explanation of 106 N.E.

† From Views and Borings, Vol. 1, p. 247. The house referred to is perhaps the old peel-tower or bastel-house situated 500 yards N.W. from where the Edinburgh Road crosses the Ottercops Burn.

Digitized by Google

	Ft.	In.
Grey mettly stone	1	6
Mixture whin	1	6
Mixture whin and white post with water	10	0
Mixture whin and mettle stone	4	6
Strong LIMESTONE, or mixture whin, with water	12	0
Blue-grey mettle stone with strong girdles	16	0
White post	4	0
Strong post, with mixture whin girdles and water, which rose to the top	7	6
In blue-grey mettle stone with post girdles	40	6
	120	2

The northern part of the district now being described (Todholes, Monkridge, &c.), lies beyond still another easterly and westerly line of fault, which, extending along the side of Raylees Burn, again throws down the beds upon the north. The beds which it brings down cannot be identified, but they certainly belong to the Upper Limestone Series. The strata have assumed a northerly dip. A coal seam, said to be nearly 2 feet thick, has been worked along the north side of Gallow Hill. The old pits lie thickest around Hillhead. In the early part of the century this seam helped to supply Elsdon with fuel. Another and smaller coal seam lies in Whiskershield Cleugh. The position of these coals in the series remains uncertain. Of the limestones, there is one spreading in an extended dip-slope up Mill Burn and Whitlees Sike. Another, near Redshaw, has above it an ironstone shale, which, when washed free from the nodules, furnished for a time some materials for brick-making. A third, very solid in its bedding, has been quarried at Monkridge, dipping N.N.E. and passing towards the large marshy flat of the river.

Some of the most interesting beds in the whole area of the Map are found in the streams south of East Nook, at the head of Whiskershield Burn. These beds, though very incompletely exposed, give us the first hint in passing northwards of a transition in the character of the series which is carried out further in the northern part of the county and fully developed in Scotland. The sections lie 200 yards south of East Nook and may be given in detail as they are seen:

LIMESTONE, pale blue, 3 feet seen.
Greenish clay with purple patches, like Tuedian Beds, 1 foot seen.

And again, the upper part of the same limestone brought back by a small fault:

Two greenish Calcareous bands.
LIMESTONE, with corals, as growing; 2 feet seen.

Another limestone a few feet underneath this one is seen a little higher up in the same small side stream of Whiskershield Burn, and gives some further indication of the same change.

	Feet.
Sandstone	0
Shale or sandstone, greenish	2
Shale with marine fossils	3
LIMESTONE, dun-coloured; corals at upper surface	6
Clay pale	3
Sandstone	0

Digitized by Google

Scarcely less unusual, and bearing witness also, though in a different way, to changing conditions, is a section in Smiddy Linn, 400 yards to the south-west.

Sandstone, solid, of medium grain, directly covering
LIMESTONE, 26 feet, partly weathering ochreous.
Thick flaggy sandstone.

There is no other instance within the area of the map in which a limestone is thus overlain without a trace of shale directly by sandstone. It certainly indicates increasing nearness to the source of the sediments. A purple and white calcareous grit may also be mentioned as lying in the stream nearer Whiskershield. The exact position of these limestones in the series is unknown; it is probably a little below the middle.

District of Elsdon, Soppit, Landshot, Hudspath, Carrick, and Penchford; together with the faulted inlier at Rimpside.—This somewhat complex district may be taken as bounded on the south by the Elsdon and Whiskershield Burns, or rather, by the fault that passes along their north side; on the west by an obscure strip of ground stretching from Soppit out to Black Stitchel on Elsdon Common; on the north by the outcrop of the base limestone (Redesdale Limestone) between Black Stitchel and Grasslees Mill; and on the east partly by the great Swindon fault, partly by the obscure outcrop of the bottom limestone on the west side of Billsmoor, and partly by the east and west fault of Darden Fell, and the edge of the map. In this district the bottom beds of the series are repeated no less than six times over between Elsdon and the Penchford Burn, chiefly by faults. We have (1) at Elsdon village, the Fourlaws Limestone well exposed in the stream: we have (2) the Redesdale Limestone brought in above Elsdon Mill, repeated (3) above Dunshield on the south side of the basalt dyke, repeated again (4) near Low Carrick a few hundred yards on the north side of the dyke, and yet again (5) at Rimpside; while lastly, the whole lower part of the group reappears (6) in the Penchford Burn. The best and longest sections appear in the Elsdon and Penchford Burns. The former has already been given in detail on page 42. The Penchford Burn section may be given as supplementing it. They are the type-sections of the greater part of the district.

Section in Penchford Burn.

	Ft.	In.
Sandstone, graduating down into shale Shale, coarse Shale, fine, with small nodules and fossils	25	0
LIMESTONE, dark blue, good	3	6
Shale, calcareous and coralline	16	0
LIMESTONE, pale blue, inferior — say	4	0
Shale with shells and Polyzoa in upper part	2	0
Sandstone, with *Stigmaria* rootlets	12	0
Shale and obscure	10	0
LIMESTONE, dun coloured, inferior, with junciform corals, 5 feet seen		
Sandstone; *Stigmaria* in upper part, worm tracks? in lower — 3 to	4	0
Shale, some plants at top, marine shells below	5	0

Digitized by Google

	Ft.	In.
Limestone, coralline, with *Productus giganteus*, 3 feet seen	3	0
Sandstones and shales, obscure, some signs of disturbance - say	125	0
Coal, *Fourlaws and Elsdon Seam*	3	0
Obscure Sandstone, passing down into Shale, coarse, with plant remains in main part; a few marine fossils below	30	0
Limestone, pale blue, *Productus giganteus*, a few corals, and (?) *Saccammina;* 11 feet seen, *Fourlaws Limestone*	12	0
Sandstone and shale Sandstone, full of driftwood Shale, about 15 feet	150	0
Limestone, good; *Redesdale Limestone* Obscure Sandstone Coal, thin; worked in some crop pits		

A comparison of the Penchford Burn and Elsdon sections will help to illustrate the fact that the upper limestones vary much more from place to place than the lower.

In Elsdon Burn more or less of this more constant part of the section is repeated by faults three times between Elsdon and Low Carrick. The Fourlaws Limestone lies in the stream beside the village, covered by its coarse and nearly unfossiliferous shale; both there and at its next appearance beyond the mill it will be found to contain turbinate corals in its upper "post" or stratum. The coal is 4 feet thick at the mill and has been worked, dipping at an easy angle northwards, not without some gentle undulation, at many places between Elsdon Mote Hills and Soppit. It is at present being worked in a plot of ground belonging to Alwinton Glebe, between Elsdon and Elsdon Gate. The sections of this pit and that of the westernmost of the whole range, now a scarcely discernible heap about 300 yards beyond Soppit Farm House, are given side by side. The first is copied from a note-book of the late Mr. T. J. Taylor; the other is kindly communicated by the present lessees, Messrs. Dowson.

Section of the Strata in the Western Pit at Soppit, near Elsdon, by Joseph Armstrong, 1846.

	Ft.	In.
Clay	60	0
Limestone	2	0
Shale, grey	12	0
Hard Freestone	9	0
Grey Shale	4	6
Coal	0	3
Grey Shale	4	3
Soft coarse Freestone	16	0
Strong grey Shale	4	0
White Freestone	4	0
White-coloured Shale	6	11
Coal	3	10
	126	9

Section of No. 1 Shaft, beside the High Road 200 yards E.S.E. from Elsdon Gate. 1880.

	Ft.	In.
Soil	2	0
Yellow stony clay	8	0
Blue stony clay	6	0
Freestone	1	0
Blue plate, fossiliferous	25	3
Very dark soft shale	2	0
Hard blue shale	1	6
Very hard grey stone	4	0
Coal	0	3
Strong blue shale, good roof	3	0
Coal	4	0
	57	0

The details of the beds are variable. Thus in No. 2 shaft 400 yards nearer Elsdon than No. 1, the section of the coal is:—

Digitized by Google

	Ft.	in.
Very hard grey stone - - - -	2	6
White beddy freestone requiring close propping -	3	3
Coal - - - - - -	3	10

The 3-inch coal seam has disappeared. The coal has the reputation of yielding a great excess of water. The section in Soppit Burn includes distinct traces of the two bottom limestones and some section of the pale impure limestone above the coal (see section on p. 42). The Soppit coal, according to Mr. T. J. Taylor in his MS. notes several times referred to, was "an open-burning coal leaving a white ash and much of it; a decidedly inferior coal to that of High Green and Garret Shields (Brown-rigg), as was proved by the Scotch trade greatly preferring the former, though sold at a higher price." The "Scotch trade" is now a thing of the past.

Returning to Elsdon Burn we find that a fault, or rather a double fault, at Elsdon Mill, cuts off the upward succession of the beds just at the coal. The first branch of this fault brings in two fairly good higher limestones and 80 feet of strata. The pathway to the mill has been cut by the miller so as to show every member of this succession, and the result is a section which better than any other in the Map gives the typical characters of the limestone zones. (See Fig. 3, p. 43.) A few yards further on, exactly at the upper corner of the mill, the second branch of the fault brings us face to face with a group of beds containing impure limestone bands with *Stigmaria*, and a 1-foot coal seam certainly belonging to the Carbonaceous Division, below the Redesdale Limestone. The dip still holds up-stream. The ascending section as far as Dunshield has been already fully detailed (p. 42). The Redesdale Ironstone Bed contains nodules of fair size, but we catch only a glimpse of it under the water of the stream.* The limestone is well exposed. Thus far the dip is moderate. But as we approach the Fourlaws Coal the beds begin to dip at an angle of 45°. The coal itself was a "dyke-seam," *i.e.*, a seam worked nearly on end. This disturbance is due to the near proximity of another fault, and at Dunshield we have, repeated once more, the top of the Carbonaceous Group† with its fetid plant-limestones covered

---

* There is now a little scar.

† A coal of the Carbonaceous group was worked in 1846 close on the north side of this fault, where the old pits can still be seen. Mr. T. J. Taylor gives the section in his MS. notes as follows:—

	Ft.	in.
Roof, 2 feet of Metal, requires much propping; above this is a freestone 9 feet thick - -		
Top Coal, left on to support roof, very coarse, with bands - - - - - -	0	5
Splint Coal - - - - - -	0	6
Parting - - - - - -		
Rough Coal - - - - -	0	5
Splint Coal - - - - -	0	6
Parting - - - - - -		
Rough Coal - - - - -	1	4
Parting - - - - - -		
Free Coal - - - - -	0	10
	4	0

Digitized by Google

by the base limestones of the Upper Series and their familiar section. The basalt dyke further on occupies still another line of fault. The Redesdale Limestone thus appears twice over. The coal has been dug out at some remote period beyond Low Carrick. The three limestones above the coal occupy the branching stream further on; they are close together, but not otherwise more like the same limestones in Elsdon and Penchford Burns than these are like one another. This section may be given.

	Feet.
Limestone, impure, with concretions of fine texture; in parts stained purple - - - -	
Sandstone with *Stigmaria* - - - } Obscure - - - - }	25 or 30
Limestone, inferior, but coralline; not less than	10 or 12
Shale - - - - - - -	1
Coaly layer and thin band of fireclay - -	1
Sandstone, with *Stigmaria* above, ripple-marked below } Shale, obscure - - - - - }	15
Limestone, inferior, coralline, 3 feet seen.	

Some of the beds further north will be referred to directly.

In Landshot Burn the section is identical with that at Elsdon, and can be followed, still dipping north, from the Redesdale Limestone up to the sandstone tracked by "worms" (or more probably crustaceans,) that overlies the pale limestone above the coal in the Elsdon section.

Passing now northward from Landshot over the line of the important E. and W. fault that crosses Darden Fell, we find traces of two limestones near the road from Elsdon into Coquetdale which, resting on the Carbonaceous Division in Billsmoor Park,—of which two of the impure plant-limestones can be seen in Carrow Rigg near the Basalt dyke,—must represent the Redesdale and Fourlaws Limestones. The coal is not yet known. This brings us north towards the Swindon fault and the Penchford section. The details of the latter have been sufficiently illustrated. The coal has been worked, and is now at great expense being re-opened, north of the ford. The new shaft is unusually deep—34 fathoms. The coal is of gaseous quality, but is cleaved by joints and hitches, apparently running parallel with the great faults of the district, which up to the present date of working (April 1886) have much impaired it. The section of the shaft is given in the Appendix (p. 138). The interval between the Coal and the Fourlaws Limestone, which was at one time much quarried and burnt near the Raw, is considerably less than in the other districts of the Map. The bottom-limestone is imperfectly seen in the burn; its position further east at Grasslees Mill is marked by a copious issue of water and a large mass of calc-marl. The unbroken continuance of its outcrop all the way out westward to Black Stitchel on the moor, seems proved by the underground passage that is known to exist between these springs at Grassless

Digitized by Google

and certain large swallow holes on the east side of that prominent hillock, chaff and other light articles having been passed between them.* Near these swallow holes, which are known as "the witch-holes," the outcrop is unusually ample.

Eastwards towards the Swindon fault the dip becomes heightened. The cheek of a parallel but smaller fault is exposed in a scar besides the stream with a patch of limestone adhering to it. Some of the beds on its south side are seen near Grasslees, dipping at 60 degrees, including a limestone with concretions. Its section may here be given :—

	Feet.
Shale, no fossils seen	5
Limestone, impure, gritty, decomposed at top into gritty material with concentric knots of pale limestone	4
Clay with knots	Thin
Pale shale	7 to 8
Sandstone, solid	

The exposure of one of the bottom-limestones at Rimpside, further to the east, is of much interest because of its insertion between the Carbonaceous Beds of Swindon Burn and the Rothbury Limestones far below—under the Fell Sandstones. The dislocation produced by the Swindon fault is thus proved to exceed in its downthrow the whole thickness of the Carbonaceous Group and the Simonside grits taken together, or, allowing 1,100 feet for the one, and a moderate estimate of 1,600 feet for the other, a total downthrow of 2,700 feet (Fig. 1.). The section is only seen in a gully running up the bank west of Rimpside :—

Section in Ravine between Rimpside and Midgy Hall.

Shale, carbonaceous-grey.
White sandstone.
Shale, carbonaceous-grey.
Sandstone, with casts of *Rhynchonella*.
Shale, thick, coarse and sandy in upper part, becoming finer-grained below.
Limestone, blueish, encrinitic, coralline.
Obscure.
Carbonaceous Division; with the coals of Hepplewoodside and Swindon.

The relation of this excellent limestone to the beds of the Carbonaceous Division, which contains no such limestone anywhere east of Redesdale, renders its identification peculiarly satisfactory. Its entirely marine character, and the carbonaceous-grey of the shales, as well as the cyclical order in the beds, contrast in the strongest manner with the Tuedian limestones of the Rothbury

* The late miller at Grasslees Mill made some experiments of this kind. The passage is said to have taken 36 hours. The distance is 3 miles.

Digitized by Google

group, with their buff and chemical-looking aspect, and their distemper green shales and unordered succession.

The exact position held in the series by the limestones near Hudspath and in the moory part of the district south of Darden Lough cannot be determined. The limestones near Hudspath and Landshot Hill are probably not far above the coal. They have all, on the whole, a prevalent dip easterly; and in a line from Landshot Hill to the Tod Knowe, they are not probably less than seven in number. The somewhat coarse grit of the Tod Crag (not to be confounded with Tod Crag north of Ottercops,) resembles the "persistent grit" of the ground to the south (106 N.E.) as last seen in Long Crag and Wolf Crag. It must approximately occupy a similar horizon. A shale very rich in fossils lies above the limestone of Colster Cleugh on the north side of East Nook. Numbers of the minute plates of Holothurians have been detected in it by MR. JAS. BENNIE. A coal, the position of which in the series is not known, was somewhat extensively wrought about the year 1810, on the north side of High Carrick, in what are still known as the Carrick Pits. According to the historian Hodgson, this coal was "much interrupted by dykes;" but of what kind these "troubles" were it is impossible to say. The coal is said to have been from three to four feet thick, and is popularly regarded as the Elsdon Seam. The number of the pits is great, partly, doubtless, because of the "troubled" condition of the coal; in the old times, also, owing to inferior drainage, ventilation, &c., pits were placed at close intervals. In these old pits the tramways were of wood, with a wooden flange nailed to one side.

District of Otterburn, Girsonsfield, Greenchesters, Shittleheugh, and Davy Shield.—This district is bounded on the south by the River Rede, on the west by the Durtrees and Stewart Shield Burns, and on the north by a large fault lying between Davy Shield Common and the Hare Cairn, and repeating the beds on its north side. On the south it lies west of the Elsdon and Soppit Burns, and adjoins the district last described.

What may be described as the heart of this district is a semi-basin of strata between Shittleheugh and Girsonsfield, one of a series of deep folds which lie one beyond another between Shittleheugh and Soppit. It furnishes one of the deepest sections found within the area of the Map. The basin is of an unsymmetrical or what may be called scuttle-shaped form, dipping gently in on the W.N.W. and then suddenly bent up on the east (as seen in Girsonsfield Burn,) at 25 and 35 degrees. Its south side is lost sight of under the drift of the valley; and the limited exposure of the strata over at Garret Shield and Troughend on the further side of the Rede scarcely help us to complete it. The highest limestone of the semi-basin is a bed fully 20 feet thick, excellent in quality, abounding in *Poteriocrinus* and other fossils, and quarried at Greenchesters. This is the only limestone that gives the outline of the basin on the Map. From Greenchesters

Digitized by Google

it extends E.N.E.; and appears, still with the same southerly dip, in the Otter Burn, east of the Long Plantation. It then turns sharply round into the Girsonsfield Burn. The outcrops of the underlying limestones are seen in that stream, and in the hill N.W. of Greenchesters. A few of the uppermost of them are seen crossing the Otter Burn; the remainder pass northwards into an obscure and dislocated region where they cannot be traced. The lowest of them that can be seen is probably one of the small limestones above the Brownrigg and Fourlaws Coal which lies (as previously described,) towards Bennettsfield. This limestone appears in Durtrees Burn at Shittleheugh. From there over the shoulder of the hill to Greenchesters the general section of the basin is as follows:—

Section across Country from the Greenchesters Limestone to the Scars at Shittleheugh.

	Ft.	in.
Limestone, Greenchesters Limestone, 20 feet seen	20	0
Sandstones, partly red Shale (space for)	45	0
Limestone, say	10	0
Sandstone, medium grain, with a *Stigmaria* bed Shale (space for)	65	0
Limestone, say	10	0
Sandstone, fine grained Shale (space for)	65	0
Limestone, say	10	0
Obscure Sandstone, medium grained Shale	110	0
Limestone, say	10	0
Obscure, perhaps containing another limestone Sandstone, 12 or 15 feet in scar, Crustacean tracks near the bottom. Shale in scar, 40 or 45 feet, upper part coarse with traces of plants, lower part fine with encrinites and small ironstone nodules.	280	0
Limestone	5	0
	630	0

The shales are represented by hollows. Of course the full details of the section cannot be seen, as it is taken across the open country. The long interval above the scar at Shittleheugh must be supposed to be occupied by the grit of Aid Crag, Black Crag, &c. But there is only a grassy slope to represent it. The Greenchesters Limestone supplies Redesdale with the small quantity of lime now used in the valley; in former times it was in great demand.*

The section at the east end of the basin near Girsonsfield gives us further details of the beds, and is flanked on the south-east, as the other is on the west, by the Fourlaws Coal. There is a range of deserted pits south of the house, worked off towards the Otter

* This limestone may perhaps represent the Oxford Limestone of the country further north.

Digitized by Google

Burn against a fault. West of Closehead again, we have both the coal and the two bottom-limestones. The section of Allen's Close Colliery is given in the list of borings and sinkings, published by the North of England Institute of Mining Engineers (Vol. I. p. 8).

Section of Allenshead or Allensclose Colliery, Closehead, near Elsdon.

	Ft.	In.
Clay	7	0
Coal	0	6
Marl	2	0
Metal	6	0
Marl	2	0
Whin	1	4
Metal	2	6
Whin	0	8
Black Plate	2	0
Coal	0	1
Red Freestone	9	0
Marl	3	0
Coal	0	1
Freestone	9	0
Black Metal	7	0
Whin	1	4
Metal	0	4
Black Stone	7	0
Whin	1	6
Grey Stone	10	0
Grey Plate	3	0
Blue Metal	0	10
Coal	2	6
	78	8

The seam is said to be variable, and to be cut through by "ancient washes" or stone dykes. Thirty inches was about its average thickness.

Four hundred yards straight west from the house some shale, containing a few marine remains and ironstone nodules, was thrown out in a trial pit placed some distance below the outcrop of the coal. In all probability this shale rests upon the Fourlaws Limestone—probably the same limestone that is seen beside the small stream nearer the house. The Redesdale Limestone, again, appears in a range of quarries, north from Monkridge Hall, based as usual on a marked sandstone outcrop.

It will not escape the observer that between the coal pits of Girsonsfield and Closehead the outcrops are suddenly slewed round from west of south to south of east. The very acute axis of this fold can be detected in Crossbank Wood east of Otterburn Castle. According to two borings for coal published by the Newcastle Mining Institute, respectively 52 and 109 feet deep, which appear to have been made upon this axis near the northern end of the wood, the coal was lost between the two sets of pits. More probably however the boreholes were too shallow to reach it. Near Closehead there is some more acute disturbance. The outcrops of the little coalfield of Closehead bear round to the north, and thus is formed the second fold or semi-basin of the series

Digitized by Google

referred to. At Closehead Plantation there is yet another acute axis (in sandstone) laying the strata over into an easterly dip of from 25 to 50 degrees, and presenting us with an ascending series, and a quick succession of limestones, not less apparently than five or six of them, but imperfectly exposed. The first two of them are probably the oft-repeated bottom-limestones back again; as for the others, nothing can explain their relation to the coal at Soppit except the intervention of a fault, perhaps the Swindon fault, or one great branch of it. The dip upon its north side must rapidly reduce its throw to nothing.

In the northern part of this district, towards the large downthrow fault bounding it south of Potts Durtrees, a series of limestones, indicated as usual by swallow holes and occasional grassy knolls, appear out beyond Blakeman's Law. A number of smaller faults are seen in Potts Durtrees Burn, the general effect of which is downthrow and repetition in that direction. A 20-inch coal that appears in the stream below Yatesfield is usually regarded as the Brownrigg (Fourlaws) Coal in a deteriorated condition. The limestones, probably 5 in number, between there and Blakeman's Law, are probably the limestones overlying the coal. The two lowest of them are about 15 feet apart. The first limestone north of the Law is a *Saccammina* limestone.* In the north-east of the district, towards Black Stitchel, and beyond a coralline limestone at Davyshield Hill, nothing appears at the surface except sandstone outcrops. No section (in this present district) is met in the Otter Burn until we descend it about 500 yards below Deanhead. The section at that point may be quoted.

	Feet.
Sandstone, soft, rather coarse, pale red in places, blood-red concretions at base - - - - -	
Shale, lower part with marine fossils and small nodules -	6
Limestone - - - - - -	2½
Shale, calcareous; corals and *Productus giganteus* -	3
Limestone and calcareous Shale in variable bands -	4½
Calcareous Shale - - - - -	1

The prevalent dip both east and west of the Otter Burn is at moderate angles to the southwards; but in and near the upper part of Girsonsfield Burn we meet with high dips and evident confusion.

District of Potts Durtrees and Dudlees, with parts of Wilkwood and North Yardhope.—By means of the fault referred to as bounding the district last described the strata are thrown far down on the north, and we are met on the moors beyond it by a group of not less than 8 or 10 limestones based, towards East Wilkwood, on the Carbonaceous Group as revealed in the wooded ravines that descend upon the Wilkwood Burn. The bottom-lime-

* The *Saccammina* in this specimen of limestone were badly preserved; Mr. Brady however informs me that it is perfectly safe to designate the species as *S. Carteri*, Brady. In a specimen of the second limestone north of Blakeman's Law, Mr. J. W. Kirkby recognises three species of Ostracoda. See fossil list, p. 87.

Digitized by Google

stone can be traced along a sandstone terrace half a mile straight south from East Wilkwood. In one small quarry it has been opened out to a depth of 8 feet, and is a pure and massive-bedded stone with abundant encrinites and broken shelly matter, containing *Lithostrotion, Productus giganteus*, plates of Echinidea, &c. and dipping south at 22 degrees. A chemical analysis of this limestone shows it to retain the same excellent quality that it possesses at Redesdale:—

*Analysis of Limestone half a mile south of East Wilkwood.**

Carbonate of Lime	94·19
,, ,, Magnesia	4·05
Silica	0·926
Iron (estimated as peroxide)	0·34
Alumina	0·404
Phosphoric Acid	traces.
	99·910

The Fourlaws Limestone is hardly visible. Towards the west they both lie in obscure patches; what appears to be the Fourlaws Coal (which we have seen near Yatesfield to be reduced to 20 inches of impure coal,) has been worked, only 13 inches thick, in pits (still open) between High Spoon Hill and the Crow Stone. The higher limestones are visible here and there in strips and plots of green, known as "gairs," and the sandstones stand out in linear features. The zone-like arrangement of the limestones, shales, sandstones and coaly bands of the Upper Limestone Series is seen in Stewart Shield Burn near Toft House. A coal at Toft House is said to have been two feet thick, but this report of its thickness is stated to have been exaggerated. A limestone at a ford over a small stream north-east of Dudlees,—a peculiar stone, partly of fair quality, partly gritty with a hard ferruginous skin, contains *Saccammina*. The limestones at Branshaw and Hare Cairn are tolerably thick. Both of them overlie coarse sandstones, either of which might represent the "persistent grit" of the district south of this Map. The limestone at Branshaw may answer to that of Greenchesters. At the head of the Otter Burn and northwards to Greenwood Law and Branshaw the limestones are in a rolling condition, and the Hare Cairn Limestones in passing eastwards appears to spread widely out upon long southerly slopes pitted here and there with swallow holes.

* Signed Thomas Fairley, April 23, 1873. It is communicated to me by Mr. Charles McSwarbeck, Chief Steward of Biddlestone Estate. The traces of phosphoric acid are stated as amounting to nearly one-half per cent. reckoned as phosphate of lime. An analysis of the same limestone at Redesdale (made at the Royal Arsenal, Woolwich,) is subjoined for comparison.

Carbonate of Lime	95·47
,, Magnesia	1·57
Protoxide of Iron	1·10
Iron Pyrites	0·10
Clay and Sand	1·70
	100·00

Digitized by Google

Further towards the east the whole group of limestones is entirely lost under drift. They probably pass against a fault. A portion of one of them, probably transported *en masse* by ice, appears among the Fell Sandstones near the uplying shepherd's house of Harbottle Crag. Towards the west, again, beyond Stewartshield Burn, the beds are hid in featureless slopes. Two limestones are imperfectly seen striking at the sandstone of Ridley Crag.

The disconnected out crops further west, and the coal at Bennettsfield, have already been described (p. 50).

Digitized by Google

CHAPTER VI.—FAULTS.

The faults of this district form an important chapter of its geology, as may be seen at a glance from the number of white lines on the Map, and the much-dislocated boundary-lines of the formations. The prevalent direction of the faults is E.N.E. and W.S.W. They have the same direction as the great boundary-faults of the Central Lowlands of Scotland; they are doubtless of the same general age as such master-dislocations as the Ninety-fathom and Stublick Dykes in the North of England, which are of post-Carboniferous and in the main of post-Permian age, later than the intrusion of the Great Whinsill, and yet certainly anterior to the intrusion of the Tertiary Basalts. In the north-western part of this Map the faults depress the strata chiefly upon their south sides, helping to bring us more quickly down towards the basement of the Carboniferous and the underlying Silurians as we go north. In the south-east the displacement is chiefly the other way; the beds of the Upper Limestone Series are repeated over and over again.

For convenience of reference we arrange the subject in three sections:—

I. Faults that help to form boundaries of formations; including all the faults of greatest stratigraphical importance. These are taken up, so far as is convenient, in the order of the age of the formations.

II. Other faults actually seen at the surface.

III. A very few faults inferred from the structure of the ground but not actually seen.

I.—*The two boundary-faults of the Silurian Rocks.*—The main boundary-fault of the Silurians at their south-east margin can be ascertained to within 10 or 20 yards of its actual position in Spithope Burn, where it brings the Silurians against the Cottonshope Basalts. It continues fairly well defined as far westwards as the foot of Ramshope Burn, where it appears somewhat sharply to change its position, running for about a mile up the middle of the main valley. Its maximum throw seems to be in Eaker Rigg, where it brings the Fell Sandstones down against the Silurians and cannot be much less than 1,000 feet. The other and parallel Fault, at the north-western margin of the Silurians in Ramshope, is of opposite effect, bringing down the Lower Freestones. The edge of the Silurians is a steep and smooth green bank; at the bottom of the bank, where the Freestones abut against it, there is a well marked line of springs.

Boundary-faults of the Carboniferous formations of the Map.—The strong east-north-easterly and west-south-westerly trend of the faults is strikingly displayed in Upper Redesdale. The

Digitized by Google

only exception worth mentioning is in Cottonshope, on the east side of Raven's Knowe. The dislocation there is not actually seen, but its probable line is marked by a rude feature running N.N.W. and the displacement is evident from the want of space for the Cementstone group between the Fell Sandstones and the Cottonshope Basalt. The more important faults of the district, however, are those of Byrness Hill and the Dour Hill-end, which are distinctly of the prevalent trend. The two Byrness Hill faults are conspicuous from the country around by their displacement of the sandstone cap of the hill. The rough freestones are brought down against the smooth slopes of the Cementstone beds. One of these two faults, it cannot with confidence be said which, (though on the map it is taken to be the southern one,) is probably continuous with a fault that passes westward along the broken edge and discordant features of the fell north of Cadger Bog to Chattlehope Spout, where it enters a gully (in the face of a scar 200 yards north of the waterfall,) filled with a vein, hading south, of clay "dowk"—*i.e.* a crushed shaly vein-stuff. In the opposite direction again, these faults, separately or combined, might account for the indefinite boundary of the Fell Sandstones north of Featherwood, and for the narrow interval occupied by the Cementstone group above the porphyrite still further east.

The Dour-hill-end fault, which might from its great length—from Coquetdale into the Liddesdale Fells—be more appropriately spoken of as the *Coquet-Larriston fault*, is a powerful east-north-easterly line of fracture crossing Redesdale at Cottonshopeburn Foot, and passing on the south side of the conspicuous escarpments of the Dour Hill known as the Dour Hill-*end*. This fault is answerable for a great change in the appearance of Redesdale. It throws the Cementstone group, the soft beds of which form the smoother slopes of the upper valley, far under the surface. Even the *top* of the Fell Sandstone group, the *basement* escarpment of which runs along like a coping high on the sides of the valley, is thrown level with the bottom of the valley, or a little under it. In Redesdale, therefore, the throw of this fault cannot fall far short of 1,000 feet. Its exact position is probably marked by a massive broken scar, about two-thirds of a mile north-east of Cottonshopeburn Foot, representing fault-faces of different beds of sandstone, and again by broken shales and cementstones on the west side of the river. It cuts off two smaller inlying masses of the cementstones further west, one in Lad Clough near Black Blakehope, and another at the head of Blakehope Burn, where at one point it brings the beds side by side with a very massive false-bedded freestone, and at another seems to contain a hard breccia of sandstone. At Rigend Burn it sends off a branch upon its south side; the fork is occupied by grits of Fell Sandstone type. Another branch, but of unknown throw, probably passes southward between Blakeman's Law and the Reedswood Crags. To the east of Redesdale the fault meets an almost parallel branch with perhaps 100 feet of throw, which appears to cross the valley among the outcrops east of Ellis Crag. The main fault carries us

Digitized by Google

across to Coquetdale; running up Sills Black Burn along the north side of the broken coals and limestones of the Carbonaceous group visible in the stream; truncating Bushman's Crag near its head; and once more—doubtless the same fault—bringing the Fell Sandstones and the Cementstones together at the Calf Lee landslip, 2 miles W.N.W. of Harbottle. Its precise position there seems to be marked at the N.E. corner of the landslip, where sandstone and purple clay, with a high local dip, lie close up against greenish (cementstone) shale. Beyond this point it has not been detected. Another fault, probably a branch of the same, passes a few hundred yards to the south of the slip, and is indicated by the polished and slickensided faces hading south in Calf Crag.

The only boundary-fault of the Cement-limestone group known to Cross Coquetdale in this map, is the *Hepple Fault*, another E.N.E.-fault with southerly down-throw. This fault cuts off the limestone of the Hepple Kilns near the foot of the long dipslope of its outcrop, and brings the Fell Sandstones across the valley. It is also marked by a very noticeable break in the continuity of the beds on the south side of the Beacon near the Five Standing Stones. The Hepple Limestone is among the topmost of the Rothbury Limestones; the fault, in the valley, need not exceed 100 feet. But further west its throw is much greater, for it brings the Carbonaceous Beds far down against the Fell Sandstones. There appears, indeed, to be a "structural necessity" to suppose a fracture of opposite throw passing from the south across the broken-off ends of the Ovenstone and Hepplewoodside coal-crops, meeting the Hepple Fault not far from the Five Standing Stones, and accounting for the much greater throw of the latter west of that point. Beds of the Carbonaceous Division are thus depressed in the angle between them. The Hepple fault is last detected cutting off a limestone of the Carbonaceous group at Piper's Shaw, and crossing the stream a little further to the west with a *Stigmaria* limestone on its one side and a sandstone bent down at 50 degrees against it on the other—terminating also some crop-workings into a thin coal a few yards further on. A parallel fault further north is marked by a line of fracture and siliceous veining in the grits of the Beacon, and by a fault-face, hading north, at the head of the stream east of the Crag Shepherd's House. Two other parallel faults are seen in Keenshaw Burn.

The Swindon Fault.—One other fault can be classed as a boundary-fault of the Cementstone group in this map—the great Swindon Fault. But this powerful dislocation affects not only the beds of the Tuedian Division but also the Carbonaceous and Upper Limestone groups—all the main divisions, in fact, of the series, which it displaces to the extent of about 2,700 feet, with effects of the most conspicuous kind both upon the stratigraphy and the landscape. (Fig. 1.) It is an E.N.E.-W.S.W. fault. Its enormous downthrow is on its north side, and amounts to the

Digitized by Google

combined thickness of the Fell Sandstones and Carbonaceous beds. Thus, crossing Darden Fell, (the west end of the Simonside Hills) —from the south or south-west, after passing from the Upper Limestone series to the Carbonaceous group, and from the Carbonaceous group to the Fell Sandstones; after traversing the whole thickness of the Fell Sandstones, and descending upon the Cement-limestones at their base—we are suddenly confronted, in Swindon Burn, with the very top of the Carbonaceous group, and in Rimpside Burn with what appears to be the Bottom Limestone of the group above it. To find Tuedian Limestones again, we must pass to the north along Swindon Burn over nearly 1,100 feet of Carbonaceous Beds and about 1,600 feet of Fell Sandstones. The total displacement of the fault may thus be stated as :—

Carbonaceous group, whole thickness -	1,100 feet
Fell Sandstones, whole thickness - -	1,600 feet
	2,700 feet

The base of the Upper Limestone Series is probably in contact with the Tuedian Cement-limestones at a point about half way between the Swindon and Rimpside Burns, near the little house known as Rimpside. But there are no sections except in the streams.

The effects of the fault upon the landscape are best seen in the charming valley of Grasslees Burn, where the brown fells, with broken ridges of grey stone striking towards the fault, look down over a green, wedge-like piece of country with fields, farm houses, and limestone quarries. The mechanical effects of the fault are seen in Swindon Burn. On its south side, the flaggy composite sandstones—greenish shales with something of the colour and softness of verdigris about them, and pale limestones dip very gently south, almost lying flat; on its north side the Carbonaceous Beds are crushed and thrown on end, and at a point about 100 yards from the fault, are even inverted. The high dips for more than a mile to the north are the result of the violent down-thrust and compression. There is no other section across this fault. In Whitefield Burn and the valley further east its line is obscured and is only to be detected by some discordance in the outcrops. In Rimpside Burn there is some crumpling of shales and other signs of disturbance on its north side, but the fault is buried under boulder-clay. In Dry Sike, at Midgy Hall, some greenish shales and thin sandstones mark the top of the Cement-limestone group under the Fell Sandstones, but there is no exposure of the fault. At Billsmoorfoot it passes on the north side of the Grasslees Coal seams, but although its position is localized to within a few yards by levels on the one side and a limestone of the Upper Limestone Series a little up stream on the other, it is not itself actually seen. In this westerly direction the strong westward dip of the beds on its south side—those on the north still retaining their

Digitized by Google

inclination south,—must quickly decrease its throw. At Billsmoorfoot it is not improbable that it has already become reduced by more than a thousand feet.* Beyond Billsmoorfoot its course is uncertain as far as Elsdon Burn, where a fault in the same line and direction, but of unknown throw, crosses the stream. It cannot be identified with any of the numerous faults further west. It cannot but be noticed, however, that whereas the disturbances of the district as a rule take the form of dislocation rather than of flexures and folds, there is a strip of ground lying directly in the path of this fault that exhibits a succession of unusually acute curves in the strata—one at Laings Hill, one at High Carrick, three between Closehead Plantation and Greenchesters, and others on the further side of the Rede in Tofts Burn and perhaps in Great Moor on the south side of Troughend Common. All these folds help to extend the Upper Limestone Series northward, having thus the same general effect as the downthrow faults, and it is not improbable that the Swindon Fault dies out into them. If so we at once account for the unusual sharpness *of the anticlines* in the neighbourhood of Closehead and the steep dips at the east or south-east end of the Greenchesters basin, which give to it its peculiar scuttle-shape (p. 62). Hence doubtless also, the obscure but acute disturbances in the streams north-east from Girsonsfield, and perhaps, the "troubles" that according to Hodgson impaired the value of the Carrick Coal.

Boundary Faults of the Upper Carboniferous Formations.—The effects of the other boundary faults are limited to the beds above the Fell Sandstones. We take up first those that break the outline of the Upper Limestone Series,† next those that bring up lower beds within it.

The Darden Fault.—The Darden fault is an important fault running east and west along the south side of the Simonside and Darden Hills. Near Darden Lough its effect is to bring down the beds of the Upper Limestone Series against the upper strata of the Fell Sandstones of these Fells. The Upper Limestones are seen striking at high angles almost straight against the picturesque anticlinal fold of the Fell Sandstones at Darden Pike —which brings on Carbonaceous Beds (and probably a reduced throw) to the east and west. The maximum throw of the Darden fault in this sheet must exceed by more than a half the full thickness of the Carbonaceous group. Like the Swindon fault it very rapidly decreases when followed west. It can be indistinctly

* Any estimate however must depend upon the position and lie of the strata within a strip of obscure ground between the Swindon and Grasslees Faults, the latter a parallel fault about a quarter of a mile to the north. The hade of this fault is to the north; its throw seems to be structurally insignificant, having no effect upon the ground to the east. But the estimate can be little better than a guess.

† As already remarked (p. 20) no line had been drawn between the Fell Sandstones and the Carbonaceous group when this Memoir was written.

Digitized by Google

traced into the line of one of the Elsdon basalt dykes, and in Carrick Burn is simply one of the numerous small dislocations that repeat the bottom limestones of the Upper Series as we ascend the stream, having only about 100 feet of throw.

The Grasslees Fault has been already incidentally mentioned as running parallel with the Swindon fault on its north side. It can be seen at a turn of the Penchford Burn near Grasslees, with a small patch of limestone and shale sticking to its cheek, and with a decided hade north. The same fault accounts for the sudden termination of the "race," of pits into the 3-feet coal beside the road east of Grasslees Mill. There is no sufficient clue to its throw. Although its hade is north, a small limestone on its south side, which in the stream near Grasslees must be almost brought against the outcrop of the Penchford Coal, would seem to indicate a reversed throw slightly to the south, being most probably one of the limestones above the coal (see p. 61). There is no proof that this fault has much effect of any kind.

The Yatesfield-Yardhope Fault.—The large fault that crosses Elsdon Common towards the north-east belongs to another line of dislocation—important as repeating the Limestones of the Upper Series over about ten square miles of country on its north side. The actual line of dislocation is generally obscure, like much of the country which it traverses. The existence of a large fault with an important downthrow to the north was first discovered near Yatesfield and Potts Durtrees. The Fourlaws or Brownrigg Coal crops out in the Yatesfield Burn; and what seem to be two of the limestones that lie close together above it appear about a mile east of Potts Durtrees; and yet north of these points there is a whole succession of strata of the Upper Limestone Series including no less than ten limestones. The actual line of dislocation was found to pass a little below Yatesfield Farmhouse, where a massive grit fifty or sixty feet thick (perhaps answering to the *persistent grit* of 106 N.E.), is suddenly lost in the bank in passing south. The fault can be traced on to Davyshield Common by a discordance of the outcrop-features. It appears to truncate the Redesdale Limestone at the Black Stitchel; and the marked stratigraphical discordance between the Limestone and Fell Sandstone Series as we pass over into Holystone Burn, and the large fault at North Yardhope bringing the Carbonaceous Beds against the Fell Sandstones in that stream, are readily accounted for by the continuation of the same line of fracture with a rather more northerly direction. Its throw on Davy-shield Common must be fully 1,000 feet. North of Elsdon Parish there are several other faults "throwing" in the same direction and probably connected with it. One of them brings the Upper Limestones and the Carbonaceous Beds obscurely together W. and N.W. from Yardhope, and terminates the Wilkwood Coals against the Fell Sandstones further north; another and smaller fault accounts for the sudden termination of the coal pits N.E. from Yardhope against Fell Sandstones; and a third is

Digitized by Google

strongly suggested by the configuration of the ground N.W. from Harbottle Crag Shepherd's House and is actually detected traversing a hollow below Cold Law.

Passing westwards to the Rede along the base of the Upper Limestone Series we find cause at places to suspect much more interruption in the continuity of the beds than can appear upon the map, especially in the very unsatisfactory ground between the Crow Stone and the Rede, or, it might be added, for a couple of miles beyond it. The outcrops of the bottom limestones between the Crow Stone and the Stewartshield Burn are extremely disconnected and doubtful. Only one fault can be discovered in this interval, however, and one other on Rochester Common. The fault is placed first of these is found at the head of Ramsay Burn nearly level outcrop of a limestone, much hid under peat, is suddenly cut off along a line running W.S.W. and E.N.E. by a range of blockstrewn knolls. In this case there is certainly a downthrow to the south of this line, and the existence of the fault is placed beyond doubt at the head of Stewartshield Burn where some where the highly disturbed beds, including an ochreous limestone in violent contact with crushed shale, lie in its direct path. The other fault cuts off two limestones on the east side of Ridley Crag, and perhaps again at Ballyardley Hill, having a west-north-westerly direction. It is detected crossing a ravine near Christie's Bog. But the district is one of much obscurity.

Faults of the Rooken Outliers.—On the further side of the River Rede we meet first the faulted outliers of the Upper Limestone Series, near the ruined limekilns of the Rooken. The powerful fault which bounds these outliers on the north is seen crossing one of the Rooken streamlets in a ravine below the road going into Redesdale from North Tynedale. It must pass along the bank directly on the north side of the kiln and through Limestone Knowe. The amount of its very considerable downthrow to the south cannot be known. The other two faults which help to circumscribe the smaller of the two outliers are only known in the old coal workings or through borings. The few hundred square yards of coal that were worked out were limited on the south by a trouble traversing the strike of the beds obliquely, and on the east the coal was suddenly lost. Borings were made during "a whole winter" on the further side of these lines; but the beds met with were different.

The Gib Shield Fault.—The fault which, to the southward, brings us fairly on to the Upper Limestone Series again, passes through an east-and-west line of hollow at Gib Shield, and may have about 600 feet of throw. The discordance between the sandstones of Gorlees Pike and the limestones striking towards it at once takes the eye. The actual fault can be detected in Tarret Burn. It is then brought westward into the Carbonaceous Group, traversing the outcrops of grit south of Blackburn Common, and cutting off a 3-feet seam of coal beside Shield Sike.

Digitized by Google

Its further course is uncertain. The actual limit of the Bottom Limestones of the Upper Series seems to be a branch of this dislocation;—its path is marked by broken sandstone slickensided and veined with silicious strings.

Padon Hills Fault.—About a mile to the South of Gib Shield near Padon Hill (Trigonometrical Station 1,240 feet), there is another unmistakable boundary fault of opposite throw, *i.e.*, of 300 or 400 feet throw down to the north. It is strongly necessitated by discordance in the outcrops and a break in the stratigraphy. This fault must pass over to Ridley Shield in Black Burn, bounding the Bottom Limestones in the hollow south of Great Dodd and crushing the beds near the house.

The Tarret and Hazle-Cleugh Fault.—The plexus of faults that lies more to the south in the Highgreen district will be described on next page. Keeping for the meantime along the confines of the Upper Limestone Series we pass to the Tarret Burn, near Smiddywell Rigg, where that series is bounded, or rather truncated, by a fault of marked magnitude, the whole series of limestones striking south-west and abutting against the beds of the Carbonaceous Group, which are seen at the foot of Sundaysight Burn. The latter are comparatively little disturbed; the former, for a quarter of a mile along the stream, are thrown into every angle from 30 degrees to the vertical. This fault is not actually seen either to the north-west or south-east of the point at which it crosses the Tarret stream, the ground in both directions being drift-covered and obscure. But it seems to retain considerable influence. To the north it is still required to account for the relations between the Carbonaceous Beds and the Limestones. To the south-east it is led into an east and west fault separating between them south of Hareshawhead. This fault was proved by a bore-hole of the Hareshaw Iron Company beside the Hazle Cleugh, now the site of a "bore well" there. It is evidently decreasing eastwards. At the bore-hole its displacement must be fully 500 or 600 feet, for it brings beds which lie at least 100 feet above the Hareshawhead Coal down against calcareous grits, &c., of the Carbonaceous Group, probably two or three hundred feet below the Redesdale Limestone.

The Sundaysight and Ottercops Fault. — The fault which cuts off the Hareshawhead Coal on the north, as described on p. 47, appears to be a long undulating east-and-west fault, extending across Redesdale from Sundaysight into Ottercops Burn. It is this fault that seems first to bring the Upper Limestone Series fairly across the valley, though its beds are scarcely seen because of the drift; it is largely concerned also in throwing the limestones from the Hareshawhead district to that of High Green. The mechanical disturbance is greatest near Sundaysight farmhouse, where it approaches the Tarret fault before described, tilting and veining the beds. At Ninewell Eyes it brings the Hareshawhead Coal against the coarse grit of Millstone Edge; and after crossing the valley it breaks and terminates the

Digitized by Google

long range of sandstone escarpment which stands over the road between Hallshill and Dykenook, and passes up into the hollow of Black Burn. In this direction its effect is becoming reduced. South of Blackstur Lough it is not probably more than 200 feet, and in Ottereops Burn it seems to die out altogether.

Hareshaw Fault.—One other boundary fault of this class, though not appearing as such in the Map, must be mentioned,—that namely, which forms the northern limit to the Upper Limestone Series in the Map on the south, from beyond Bellingham, six or seven miles away, to where it enters the map south of Wishaw. Its first appearance in this map is marked by at least 600 feet of downthrow on its south side, where it cuts off the long sandstone escarpment below the Redesdale Limestone and obscurely bounds the spread of limestones south of Whaup Moss. It must certainly pass on to Wolf Crag, where there are high local dips and some discordance and crushing of the beds, but its stratigraphical effects are no longer distinct.

Returning now to the High Green district we pass in review those faults, strictly speaking boundary-faults, which are connected with inliers of the Carbonaceous Beds within the main area of the Upper Limestone Series. They are not in every case, of course, separable from the others.

The Smithy Cleugh Fault.—The section of the Redesdale Limestone and Ironstone dipping south in Smithy Cleugh has been already described at p. 48. On its north side the long slopes become dotted with old shafts into the Highgreen and Fourlaws Coal several hundred feet higher in the series. Not a trace of any fault can be discovered at the surface to account for this abutting of the uppermost Carbonaceous Beds against the Fourlaws Coal, except on the east side of the ruined Pit Houses, where there are some small quarries of shattered sandstone. Its effects, however, were detected in the pits. The coal close to the fault was mingled with spar and of no value. The deepest of the pits, close beside the Redesdale road within a hundred yards west of the branch road to High Green and North Tynedale and close beside the fault, reached the unusual depth of 35 fathoms, with little but sparry coal at the bottom. It serves to prove the fault to have fully 500 feet of throw.

Beside the quarry and lime-kiln near this junction of roads, the Smithy Cleugh Fault is met by two others, arranged, with it, triradiately. The middle line of fault passes between the quarry (which is into the Forelaws Limestone) and the Redesdale Limestone of Smithy Cleugh, and has thus rather more than 100 feet of downthrow to the south; it seems to cut off the Fourlaws limestone again just north-east of Highgreen House. The southern line of fault is short, and not actually seen; but it seems quite necessary to separate the limestone of the kiln from the undoubted Fourlaws Coal of Kiln Rigg.

Digitized by Google

The Highgreen Fault.—A more important fault is the more easterly and westerly one on the south which the latter of these two is represented as partly counteracting. This fault is best seen in the Tarret Burn at the foot of Gofton Cleugh near the basalt dyke and the old levels in search of lead, where there are highly inclined Carbonaceous Beds of laminated sandstone, shale, and some impure limestone upon its south side. The Fourlaws Coal lies in the stream 200 yards to the north, dipping into the fault at 20 degrees. From what can be seen of the strata, it cannot have much less then 900 feet of throw down to the north. So far as its direction can be made out it seems to intersect the basalt dyke at a very acute angle near the Hollinhead Lead Shafts, crossing Red Sike towards Lord's Shaw.

The Black Crag and Sundaysight Cleugh Faults.—Passing further to the south the steady upward succession near Highgreen pit (*see* page 47) is terminated against a fault on the further side of Black Crag; and in Sundaysight Cleugh we have the Redesdale Limestones, repeated twice over by another. The Black Crag Fault, necessitated mainly by the stratigraphy, shows itself by discordant dips, and some much-shattered sandstone, east of the Crag. It must have 300 or 400 feet of throw. The other, though not seen, is plainly necessary; the section of Sundaysight Cleugh is that of Redesdale, which is the key to the district, and it appears twice over almost bed for bed. Some 200 or 300 feet of Carbonaceous Beds underlie the Redesdale Ironstone shale against this fault or the obscure line where it must lie, and its throw must amount to 500 or 600 feet.

The Hareshawhead Fault.—The next fault to be mentioned is that dividing between the older and newer groups of the Hareshawhead coal-workings. This fault has not been actually proved by the levels, but the seam has been worked close up to its northern cheek N.N.E. from Hareshaw Kiln, and its position is well known to the pitmen. The kiln Limestone (the Fourlaws Limestone) would seem to abut against it not far from an old pit 200 yards west of Rowantree Linn. The pit is said to have been 20 fathoms deep; the throw of the fault, if so, is defined at that point as about 200 feet down to the north.

Faults of the Elsdon District.—The few remaining faults of this class are those of the Elsdon District, all of them connected with the repetitions of the bottom beds of the Upper Limestone Series.

The Ravenscleugh and Raylees Faults.—The fault passing a little south of west beside Ravenscleugh is a downthrow to some unknown amount upon its north side. The Carbonaceous Beds are just beginning to emerge from below the Redesdale Limestones in the ravine south of the house, when this considerable fault intervenes. It is itself best seen in Raylees Burn south of Hillhead, with the Redesdale (?) Limestone on one side (the south,)

Digitized by Google

and another veined limestone notched in against it in the stream-bed on the other. Two limestones appear to be cut off further east along the same line. An almost parallel fault is to be detected running E. 15 S., lower in the stream, between Hillhead and Ravenscleugh; a limestone fault-face abutting against nodular shale with *Chonetes*, shows a northerly hade.

The Elsdon Fault.—What must be termed the *Elsdon* Fault is concealed beneath the drift and alluvium of the Elsdon and Whiskershield valley; but it is emphatically necessitated by the dip of the Upper Limestone Series down the southern slopes of the valley against its lowermost members in the Soppit, Elsdon, and Landshot Burns. That this fault is both large and long is seen when it begins to run clear of the valley towards Eastnook. It first cuts off the long birch-grown crag south of Landshot Hill, then the thick limestone of Colster Cleugh, and passes into the next Map (109 S.W.) beside the broken edge of Tod Crag. But the position of the beds upon its south side is nowhere known, and it is impossible to form an estimate of the amount, as distinguished from the direction, of its downthrow. The latter is evidently to the south.

The little plexus of faults in Elsdon Burn between Elsdon and Low Carrick serves at first to render the interesting sections of this stream somewhat perplexing. The leisurely ascent, not without a trace of gentle undulation, from the Fourlaws Limestone beside the village to the coal at Elsdon Mill, is suddenly brought to an end by a downthrow fault a few yards south of the mill, and the full section between two upper Limestones appears beside the Mill Road, dipping north at from 25 to 35 degrees (see Fig. 3, p. 43). This excellent section cannot be identified in its details with those higher in the stream, the uppermost of which are as much as 170 feet above the coal (see general section in Elsdon Burn, p. 42). This fault has probably therefore fully 200 feet of downthrow upon its north side. Scarcely 50 yards further on, the section in the roadway is cut off by another. A bed of shale retain a *Stigmaria* Limestone and 1-foot coal that lies up against this fault at one edge of the mill-dam evidently and distinctively belong to the Carbonaceous group. This *second* fault must have not less than 450 feet of downthrow to the *south*. It seems to be in the act of joining the other from the N.E. and probably passes the faulted-off end of the limestone outcrop at the Limekiln Quarry east of the main road. Their combined effect can only be surmised; they are probably not unconnected with the breaking-off of two limestone outcrops between Dunshield and Fairneycleugh.

The section now carries us without any actual break to Dunshield; but a fault lies hid in the right bank of the stream within a hundred yards distance all the way, as was proved when the "edge seam" of the Fourlaws Coal was followed in that direction. This fault crosses the stream just above Dunshield. On its S.W. side we find some flaggy sandstones about 70 feet above the coal; and on its N.E. side, the thin coals, calcareous grits, and fetid limestone

Digitized by Google

bands of the Carbonaceous group. The throw of this third fault is about 300 feet. A very few yards to the west it is complicated by one or two others, as indicated by the non-emergence of the Fourlaws Coal in the section of Folly Sike, and a sudden break and reversal in the dip.

The last repetition of upper beds in Elsdon Burn is at the Basalt Dyke, which occupies a fault with about 100 feet of downthrow to the south. But this fault is really only the much-reduced Darden Fault already described. With this we conclude this detailed description of the boundary-faults of this Map.

(II.) The few faults, mostly unimportant, whose effects are, so far as known, limited to the interior of the formations, we pass very rapidly in review. Doubtless there are many more of them than are known, especially as the larger number of them traverse workable coals. Thus in the Carbonaceous Series we have the north-and-south fault that obscures the coal east from the Rookenpithouse; the N.E. and S.W. fault passing beside the coal seams at Midgy Holes in Tarset; the "trouble" in the old coal workings near Watch Crag, Hunter Burn; the fault against which a 3-feet coal was lost between Tarret Burnmouth and Gatehouse; and the faults affecting the Plashetts Coal in the Falstone neighbourhood. These almost exhaust the list. There is one rather conspicuous dislocation crossing the north end of Whiteheugh Crag on Comb Moor, very noticeable from Emblehope; but its effect is unknown. Another, a downthrow on the south, enters the head of Harper Burn from the west, between some old coal workings in the stream and the swallowholes under Harper Crag, but it is lost at once under drift and peat.

The *faults of the Plashetts Coal* deserve some notice. The existence of the boundary-fault of the coal workings under Hawkhope Moor was sufficiently proved about 400 yards E.N.E. from the end of Fox Crag. Its throw or hade is not known; it is said to have been almost without hade, and the old levels are not now accessible. But there is every reason to consider it a downthrow on the N.E. The coal was "half-burnt" for 40 yards on its west side, doubtless from the heat of the basalt represented by the "china-like" clay once known as the *Plashetts Plaster* (*see* p. 100). The small faults of the coalfield for at least a mile to the west,—hitches of only one, three, and four feet, ran nearly parallel with the larger throw. To the north it seems to swerve past the east end of Rabbit Crag. To the south, according to all the stratigraphical evidence, it must pass across the head of Falstone Burn. But before it crosses Hawkhope Burn it probably encounters a large fault of opposite throw making from the direction of Hawkhope Plantation, (where there is a manifest dislocation in the stream,) and from a point west of Carshope Plantation where the Plashetts Coal lies in the same line of strike with a quite different seam. The Piper's Cross Limestone lies deeply depressed within the

Digitized by Google

fork ;—by the one fault, that on the west, it is thrown down some 450 feet, and by the other, the Plashetts boundary-fault, 500 or 600 feet. At Falstone Burn head the latter may be estimated as amounting to 360 feet; it then appears to turn southward by Slaty Ford in Thorney Burn, where there is a marked dislocation cutting off the grit of the Hillhouse Clints, and bounding the old Thorneyburn coal workings on their west side.

Several smaller faults were known in the Plashetts Coal workings straight north from Falstone. The largest of them, beside the principal shaft (20 fathoms deep, but largely boulder-clay,) is stated by Mr. Michael Robson to have brought the Dun limestone down against the coal. The interval between these beds in Carshope Plantation is 90 feet.

All the more important faults of the Upper Limestone Series have been already mentioned. The few that are not boundary faults chiefly affect coal seams. Thus the little coalfield at Brownrigg, like that at Haresbawhead, is divided into two areas, one of which is worked out, by a W.N.W.–E.S.E. fault. In order to prove its throw a pit was sunk on its north side in a line with the known outcrop of the coal on the other. This pit is said to have been 24 fathoms deep; the throw of the fault being thus fairly estimated as about 140 feet. With this exception the Brownrigg coal has been remarkably free from "troubles." A smaller fault crosses its outcrop in Rattenraw Burn, with a downthrow (of perhaps 60 or 80 feet) on its west side.

(III.) Of most of the faults the position is at some point or other known. There are a very few, however, that are purely inferential. Thus, on Corsenside Common, the bottom limestones of the Upper Series, which dip where last seen, strongly to the east, are probably separated from the Carbonaceous beds in the Rede by a north and south fault throwing down to the west. Upon the map it is continued on to the west side of a peculiar stigmarian limestone in Tofts Burn (see p. 51) at a point at which there are signs of disturbance. Again, the ascending series of Upper Limestones between Closehead Plantation and Soppit near Elsdon must certainly be separated by a fault, or a very acute twist, (of which there is no symptom), from the Elsdon Coal. Its direction is probably south-westerly, and its throw must be 400 or 500 feet down to the east.

Digitized by Google

CHAPTER VI.—PALÆONTOLOGY.

Of this chapter, the lists of the fossils which have been collected from the several fossiliferous formations of the district,* form the bulk and the really important part. To each list there is prefixed, however, a short introduction, chiefly bearing upon the distribution of the fossils in the beds, and the palæontological conditions that obtained at the time. In each case there is given a numbered list of the localities from which collections were made; followed by the list of fossils, with the references to localities denoted by the numbers.

The fossils have been identified by Messrs. G. Sharman and E. T. Newton, Palæontologists to the Geological Survey; with the exception of the plants, which have been named by Mr. R. Kidston, and most of the Ostracoda, which have been named by Mr. J. W. Kirkby.

Upper Silurian Rocks.—*Wenlock Beds.*

The few fossils that have been detected in the Wenlock Beds of this district include only a few graptolites, and an Orthoceras. They are obtained from the finest of the shales, which have generally a finely striped appearance. The grits and coarse shales seem to be without fossils.

Fossils.

Hydrozoa	Monograptus Flemingii, *Salt.*	Lumsdon Burn and Spithope Burn.
	Monograptus, *sp.*	Lumsdon Burn and Coomsdon Burn.
Cephalopoda	Orthoceras (Creseis) primævum, *Forbes*	Lumsdon Burn.
	Orthoceras, *sp.*	Coomsdon Burn.

Carboniferous Limestone Series.

Lower Tuedian Beds.

The fossils of the Lower Tuedian Beds, of the scanty fauna and flora of which this is the first fairly representative list that has been published, are such as might be expected to characterise the northern and extreme in-shore edge of the marine area of the Carboniferous Limestone, which lay, it is quite clear, open and without any intervening barrier, to the south of this district. By far the larger proportion of the beds, including most of the greenish and ashy-grey shales and all the purple bands, are with-

* Chiefly by Mr. John Rhodes, Fossil Collector to the Geological Survey of England, assisted in the upper part of Redesdale by Mr. Arthur Maconochie, one of the Fossil Collectors of the Survey of Scotland.

Digitized by Google

out distinctive fossils of any kind. The few marine remains are restricted to the limestones and some of the darker shales. The plants occur chiefly in the darker shales.

Allowing for the alternations of condition and *habitat* which characterise all the Carboniferous formations in the North of England, the fossils bear something perhaps as nearly approaching a littoral facies as the Carboniferous of Britain can show us. The scanty marine fauna is represented by three or four species of poor corals, some encrinites, always very small, and a group of Lamellibranch and Gasteropod molluscs, besides a considerable number of fishes, which like the other fossils, are all of Lower Carboniferous species.* There may also be mentioned in this introduction some large imperfect specimens of Nautilus and a few small Brachiopods, found many years ago near Barrow Scar, which do not appear in the list.† One of the most interesting facts emphasised by the fossil lists of this chapter is the relative distribution of the Lamellibranchiata and the Brachiopoda. Of Brachiopods, in the Tuedian Beds, there are remarkably few. The Lamellibranchiata are fairly represented; they dwelt towards the shore, though by no means exclusively so, while the Brachiopoda, as will be shown by their increasing numbers in the other lists, were swarming in the outer seas.

The flora, which is far from rich, is, according to Mr. Kidston, entirely of "Calciferous Sandstone type." The plant remains, as we have remarked, occur chiefly in the darker shales. Here and there we detect the presence of land-surfaces, represented by soles of plant-growth thinly penetrated by small rootlets, often with a dark layer of shale and a scattering of vegetable remains, or more rarely a coaly layer, above the roots. Sometimes a cementstone is found resting above the carbonaceous layer. It is clear that the subsidences accompanying the deposit came in jerks, marked by suddenness and to some indefinite extent by periodicity, alternating with siltings-up of the surface.‡ In at least one case a cementstone is penetrated by the rootlets, indicating how shallow was the water in which the limestone-builders lived. What animals they were that were chiefly concerned in the formation of these Tuedian Limestones is not yet made clear.

There is no very remarkable abundance of Entomostraca. Interesting groups of other Crustacea, mostly of new species, which Mr. B. N. Peach is about to describe, and which he will show to be of the Schizopod order, lived in some of the muddy shallows, perhaps embayed in hollows of the neighbouring shore. On the shore and in the swamps there was no lack of the air-breathing scorpions of the period.

---

* I am indebted to Dr. Traquair for looking over the list of fishes.

† The Nautili were found, as I am reminded by Prof. Lebour, in a thin impure limestone in the River Coquet between Alwinton and Barrow Scar, by Mr. H. Walters, a fossil collector of the Survey; the Brachiopods, in a dark shale of the Scar by Mr. Lebour himself.

‡ The evidence throughout the Carboniferous Limestone Series of this district seems to speak uniformly of subsidence and the silting-up of the shores or sea-bottoms by means of deposit. There is no evidence of upheaval.

Digitized by Google

A short summary of the list may be added. Of plants the species are five or six; of annelids, two, (*Spirorbis helicteres* pretty generally diffused in the limestones, though not common); of Ostracoda, three; of other Crustacea (Schizopods), 12, eight of them being new species; of Scorpions five; of Brachiopoda there is only a single species, from a limestone band near Featherwood; there are four species of Lamellibranchiata, three of Gasteropoda, and one Orthoceras. The fish are of six or seven kinds.

Localities.

REDESDALE :—

1. Coomsdon Burn, half a mile above junction with River Rede. Grey sandy Shale.
2. The same. Limestone.
3. Chattlehope Burn, 2 miles above Chattlehope Farm House. Limestone and Shale.
4. Chattlehope Burn, opposite the House. Black Shale.*
5. Hawk Burn. Clayey Shale.
6. Spithope Burn. Grey sandy Shale.
7. Sills Burn, half a mile north of Featherwood. Shelly Limestone.

COQUETDALE :—

8. River Coquet, 200 yards above Sharperton New Bridge. Yellow Limestone.
9. River Coquet, 500 yards below the same. Dark sandy Shale.
10. River Coquet, 600 yards below the same. Limestone weathering yellow.
11. Holystone Burn, opposite Holystone Church. Limestone.
12. Hepple Kiln Quarry, half a mile north of Hepple. Limestone; the "White Rock."
13. The same. Limestone; the oolitic "Pebbly bed."
14. Whitefield Burn, half a mile south of Whitefield House. Limestone, with concretions.

Fossils.

		No. of Locality in foregoing List.
Plantae	Adiantites, *sp.*	6
	Alcicornopteris convoluta, *Kidston*	1, 6, 7, 9
	Caulopteris minuta, *Kidston*	10
	Lepidodendron veltheimianum, *Sternbg.*	3
	Lepidodendron, *sp.*	4
	†Lepidostrobus, *sp.*	5
	Stigmaria ficoides, *Brong.*	—
Actinozoa	Chætetes, *sp.*	2, 13, 14
	Chætetes?	11
	Syringopora, *sp.*	8
Annelida	Serpulites?	1
	Spirorbis helicteres, *Salter*	1, 3, 10, 11, 14
	Serpula (Spirorbis) sub-annulata, *Portl.*	14

* Mr. Peach points out to me the presence of a slight development of cleavage in this shale. The thin-shelled Crustacea which it contains are slightly drawn out and distorted. This may be due to the local disturbance marked by a high dip in the stream at the upper end of the Chattlehope infield. I observe also a trace of fluxion-movement in the micaceous particles of the stone.

† The plants in this and the following list have been determined by Mr. R. Kidston.

Digitized by Google

		No. of Locality in foregoing List.
Crustacea - -	Acanthocaris scorpioides, *Peach*	4
	Anthrapalæmon Etheridgii, *Peach*	1
	A. Woodwardi, *Eth. jun?* -	1, 4
	A. simplex, *Peach, M.S.* -	1
	A. sculptus, *Peach, M.S.* -	1
	A. near to A. formosus, *Peach* -	1
	Palæocaris scoticus, *Peach* -	1
	Palæocrangon elegans, *Peach* -	5
	P. northumbriensis, *Peach, M.S.*	1
	P. robustus, *Peach, M.S.* -	1
	P. laciniatus, *Peach, M.S.* -	4
	P. minutus, *Peach, M.S.* -	1
	Pseudogalathea rotunda, *Peach* -	1
	P. redesdalensis, *Peach, M.S.* -	1
	P. carinata, *Peach, M.S.* - -	1
	Beyrichia giganteus, *Jones* -	4
	Cytherella, *sp.* - - -	*See p.* 13
	Kirkbya spiralis, *Jones & Kirkby*	*See p.* 13
	Leperditia sub-recta, *J. and K.* -	*See p.* 14
Arachnida - -	Eoscorpius giganteus, *Peach* -	1
	Eoscorpius? - - -	4
	Glyptoscorpius (Cycadites) caledonicus, *Salt* - - -	1
	G. argus, *Peach, M.S.* - -	1
	Glyptoscorpius, *sp.* - -	1
	Prestwichia, *sp.* - - -	1
Brachiopoda -	Rhynchonella pleurodon, *Phil.* -	7
Lamellibranchiata -	Anthracoptera obesa, *Eth. jun.* -	1, 4
	Cypricardia modiolaris, *M'Coy* -	1
	Modiola Macadami, *Portl.* -	1, 3
	Modiola, *sp.* - - -	13
	Myalina Verneuilii? *M'Coy* -	7
	Myalina, *sp.* - - -	1, 4
Gasteropoda -	Dentalium, *sp.* - - -	7
	Murchisonia angulata, *Phil.* -	10
	Turbo, *sp.* - - -	13
Cephalopoda -	Orthoceras, *sp.* - - -	1
Pisces - -	Canobius Ramsayi, *Traq.* -	1
	Helodus, *sp.* - - -	1
	Helodus? - - - -	10
	Holurus Parki, *Traq.* - -	1
	Rhizodopsis, *sp.* (scale) - -	1
	Strepsodus, *sp.* - - -	1, 5
	Polyrhizodus? - - -	10
	Pæcilodus (Deltodus) - -	7
	Palæoniscoid fragments - -	1

The Fell Sandstones, or Upper Tuedian Beds.

With one exception, on which nothing can with safety be founded, the fauna of the Fell Sandstones, in at least the whole north-eastern part of the district is *nil.* The red clays among the grits have yielded nothing organic either to the hammer or under washing for Microzoa. Imperfect fragments of a large shell supposed to be *Anodonta Jukesii* (the exception referred to) were observed by Mr. G. A. Lebour in 1873 in a loose piece of sandstone on the slopes of the Beacon (in Coquetdale) not far from the Five Standing Stones. But this specimen seems to have

Digitized by Google

been lost some years before it was recognised.* Some vegetable remains, evidently of driftwood, chiefly coniferous, can be seen scattered in a sandstone below the pebbly grit of Yearning Crag, among the Harbottle Hills. The coarser grits appear to be barren.

In the western part of the district there are probably some fossils associated with the several small coal seams near Chattlehope Spout, &c. (see pp. 16, 19). They have not been collected.

Carbonaceous Division.

Passing over from the Cementstones to the Carbonaceous Group we note at once the proofs of a partial change of habitat in the waters, and the different facies of the fauna. It is now more strongly marine. The mean sea-level was considerably higher. But the conditions remain at least as mixed and changeable as during the deposit of the Cementstones. There were constant and, geologically-speaking, rapid alternations of shallow sea and widespread swamp, with unnumbered changes of conditions intermediate between these two extremes. The limestones are seldom free from fragments of vegetation; they are often fetid also from the inclusion of organic matter (as well as of mud and grit); the silts are dark with the tincture of peat which they contained. They were deposited upon the limestones with so little interval and were so quickly overspread with vegetation that in numbers of cases the rootlets struck down into the limestones. It is not difficult to detect almost everywhere the traces of a cyclical order in the repetitions of the beds, due to these alternations. Thus the limestones often rest upon coals, and are generally covered by more or less shale sometimes succeeded by sandstones. But this arrangement is still with few exceptions imperfect—as if confused by a great number of jerks and pauses during the subsidence.

A considerable change in the character of the fauna can be detected *over the horizontal extent of the Map.* Towards the north-east it is scanty; towards the south-west it is increasingly abundant and more and more marine. Several times over, as proved by some good limestones, this south-western part of the district was covered by a clear and coralline sea. But on the whole the corals are still few in number, the encrinites very generally small in size; and of the Brachiopoda the species and perhaps also the individuals continue to be less numerous than those of the Lamellibranchiata and Gasteropoda. The increase of their numbers, however, is marked, and could probably be detected by sufficiently careful examination within the area of this single

* Prof. Lebour is good enough to inform me of the circumstances. The piece of sandstone he believes to have fallen from the outcrops of the Fell Sandstones on the side of the hill. The specimen was not recognised at the time and was lost before it could be submitted to a palæontologist; and, unfortunately, there was no note or sketch of it preserved.

Digitized by Google

formation, which as we have seen, is so much more marine towards the south-west, and so much more like the Coal-Measures towards the north-east. We are also led towards the conclusion that the fish-life of the period was more abundant nearer the shore. The decline in the number of the species, and still more of the individuals, is very noticeable.

Some of the sections most typical from a palæontological point of view may be just mentioned. The evidence of the rapid alternations of conditions can be studied in the cutting at Midgy Holes (p. 21), and in Greenhaugh Burn; it is to be detected almost everywhere. The *cyclical order* can be made out in the section of the Piper's Cross Limestone in Hawkhope Burn, and the Plashetts Dun Limestone in Falstone Burn, and in the limestone in the stream north of Highfield. All these sections are like single cycles taken out of the Upper Limestone Series. The section above the Plashetts Coal, again, is well worthy of study as illustrating the palæontological conditions which followed upon the formation of this the chief coal seam of the Division in this district. It will be found on page 34; but it is worth repeating here, more from its palæontological point of view:—

Shale, with 15 species of Lamellibranchiata, five Gasteropods, four Brachiopods, and a Cephalopod.
Shale with Cypris bands (*Leperditia scotoburdigalensis*) and some fish scales (*Elonichthys*), and with plants and *Lepidostrobus fimbriatus*, and a specimen of *Pleurotomaria*, sp.
Some bituminous Shale with fish scales.
COAL.

We conclude this introduction as before with an enumeration of the species:—Plants, 4; Coral, 1; Crustacea, 8 (1 Trilobite and 7 Ostracods); Brachiopoda, 10; Lamellibranchiata, 18; Gasteropoda, 12; 1 Pteropod, 1 Cephalopod, and 4 Fishes.

Localities.

REDESDALE:—

15. Sills Burn, near Pity Me, two miles north from High Rochester. Thin Shelly Limestone. (*See* section on p. 25.)
16. Sills Burn, quarter of a mile west from High Rochester. Impure Limestone bands in Shale.
17. Ralph's Cleugh, Blakehope Burn. Grey Sandy Shales.
18. The same. Calcareous band above Sandy Shale.

NORTH TYNEDALE:—

19. Cat Cleugh, tributary of Tarret Burn, at John Side, fully one mile N.N.E. of Greenhaugh. Impure Limestone bands in Shale.
20. Trial level for Coal, 1¾ miles west of Falstone Church and 100 yards E. of Shilburnhaugh. Grey calcareous Grit.
21. Falstone Burn, ¾ mile N.E. from Falstone Church. Shale with ironstone balls.
22. The same. Shale closer above the Plashetts Coal.
23. Head of Falstone Burn. Shallow Coal pit. Hard Cyprid bands 5 feet above the Plashetts Coal.
24. The same. Clayey Shale above Cyprid bands (the same as No. 22).
25. Old Limestone quarry on Hawkhope Hill, 1¼ mile N. of Falstone Church. The Piper's Cross Limestone, and Shale above it.
26. Hawkhope Burn, 1½ miles N.W. from Falstone Church. The same.

Digitized by Google

Fossils.

		*No. of Locality in foregoing List.**
Plantæ	Cardiopteris (nana, *Eichwald*)	*p.* 39
	Lepidostrobus fimbriatus, *Kidston*	21, 24
	Stigmaria ficoides, *Brong.*	—
Actinozoa	Lithostrotion junceum, *Flem.*	26 and *p.* 51
Echinodermata	Archæocidaris, spine	21
	Crinoid ossicles	16, 21, 25, 26
	Lepidodiscus Lebouri, *Sladen*	*p.* 41
Crustacea	Bairdia plebeia, *Reuss*	*p.* 65
	B. Hisingeri, *Mün.*	*p.* 65
	Beyrichia arcuata? *Brady*	21
	Carbonia fabulina, *J. and K.*	*p.* 21
	Cytherella extuberata, *Jones and Kirby*	*p.* 21
	Cytherella, *sp.*	21
	Kirkbya costata, *M'Coy*	21
	Leperditia scotoburdigalensis, *Hibb.*	23 and *pp.* 21, 34
	L. Okeni, *Mün.*	*pp.* 21, 65
	L. sub-recta, *Portlock*	*p.* 21
	Leperditia, *sp.*	16, 19, 21
	Phillipsia seminifera, *Phil.*	*p.* 41
Brachiopoda	Athyris Royssii? *Lev.*	21
	Discina nitida, *Phil.*	24
	Lingula mytiloides, *Sby.*	17, 22, 24
	Productus giganteus, *Mart.*	25
	P. Cora, *D'Orb.*	24
	Rhynchonella pleurodon, *Phil.*	15, 17, 18, 19, 21, 24
	Spirifera glabra, *Mart.*	21
	S. laminosa, *M'Coy*	21
	S. trigonalis, *Mart.*	18
	Spirifera, *sp.*	15
	Streptorhynchus crenistria, *Phil.*	20
Lamellibranchiata	Avicula angustata, *M'Coy*	24
	A. gibbosa? *M'Coy*	22
	A. micropterus, *M'Coy*	22
	Aviculopecten interstitialis, *Phil.*	15, 17, 18
	A. docens, *M'Coy*	24
	A. near to A. tabulatus, *M'Coy*	21
	Axinus axiniformis, *Phil.*	22, 24
	Cypricardia socialis, *M'Coy*	18
	C. sinuata, *M'Coy*	22
	Dolabra gregaria, *M'Coy*	24
	Edmondia sulcata, *Phil.*	24
	Leda attenuata, *Flem.*	15, 16, 20, 22, 24
	Leda, *sp.*	19
	Modiola megaloba, *M'Coy*	24
	Myalina lamellosa, *De Kon.*	18
	Myalina, *sp.*	17
	Pteronites angustatus, *M'Coy*	24
	P. Thompsoni, *Portl.*	22, 24
	P. ventricosus? *M'Coy*	22
	Sanguinolites plicatus, *Portl.*(? = *S. irridinoides, M'Coy*)	21, 24
	S. irridinoides, *M'Coy*	22, 24
	Sanguinolites, *sp.*	15, 20

* In a few cases the reference is to the pages of the preceding chapters.

Digitized by Google

		No. of Locality in foregoing List.
Gasteropoda -	Actaeon? (resembles Macrochilina canaliculata, *M'Coy*, and Cylindrites carbonarius, *De Kon.* - - - -	17
	Loxonema, *sp.* - - -	21, 22, 24
	Murchisonia angulata, *Phil.* -	19
	Murchisonia (Aclisina) striatula, *De Kon.* - - -	17
	Macrochilina imbricata, *Phil.* (? M. striata, *De Kon.*) -	17
	Natica lirata, *Phil.* - -	17
	Naticopsis plicistria, *Phil.* -	25, 26
	Naticopsis plicistria? *Phil.* -	17
	Naticopsis, *sp.* - - -	20
	Pleurotomaria, near to P. radula, *De Kon.* - - -	15
	Pleurotomaria, *sp.* - -	20
	Bellerophon decussatus, *Flem.* -	15, 17, 22
	B. interlineatus, *Portl.* - -	19, 24
	B. Urei, *Flem.* - - -	24
	Dentalium ornatum, *De Kon.* -	24
	Dentalium, *sp.* - - -	15, 20, 22
Pteropoda - -	Conularia quadrisulcata, *Sow.* -	16
Cephalopoda -	Discites subsulcatus, *Phil.* -	24
Pisces - -	Cochliodus (Psephodus) magnus, *Ag.* - - - -	*p.* 37
	C. (Deltoptychius) - -	*p.* 37
	Elonichthys, scales - -	23
	Rhizodus? - - -	*
	Fish scales - - -	20

Upper Limestone Series.

Calcareous Division.

In the Upper Limestone Series the mean position of the shoreline was evidently still more distant. We find ample proofs of the periodic overspread of a tranquil, clear, and coralline sea, containing the marine fauna of the Mountain Limestone, throughout the whole district, brought in as if by considerable strides of depression many times repeated. Upon each depression there seems to have ensued a long-quiescent interval during which the undisturbed marine life built up the bottom with solid beds of calcareous matter. Fine silts from a distance then made their appearance; the marine life died out in the mud; the deposits gradually grew coarser, and the shallowed water was at length ousted by a swamp or peat moss. The palaeontological cycles answering to these events are extremely well marked. Limestones with plant remains or roots are now unknown; the plants are invariably restricted to the upper part of each cycle; the marine remains as distinctly belong to the lower part; and the palaeontological arrangement thus goes into two main divisions.

* From loose shale at the mouth of the Plashett's coal level at Falstone Burnhead.

Digitized by Google

Palæontological Cycle of the Upper Limestone Series.

LIMESTONE.

PLANT REMAINS.
- COAL, or root-beds, or beds more or less carbonaceous, with sandstones and shales.
- Sandstone, not unfrequently current-bedded and containing drift-wood of the size of small snags.
- Shale, generally sandy in upper part; plant remains, generally mere dark impressions as if decomposed by drifting.

MARINE REMAINS.
- Shale finer, and with marine remains, in increasing numbers towards the bottom.
- LIMESTONE, corals (when present) in the attitude of growth.
- COAL, or Root-beds, &c

The larger corals of the Limestones, especially the Lithostrotions, are generally found erect, in the attitude of growth, as if spreading from the surface of the limestone up into the mud that choked them. It is interesting to note that their mode of growth is invariably floriform and limited to a horizontal surface. They were not reef-builders. The calcareous portion of the shales is of uncertain thickness, varying from two or three feet to 40 feet or more, according to the rapidity with which the sediment-bearing currents set in. The slow disappearance of the marine remains is an interesting study: they are seldom or never found in the upper, or more sandy, part of the shale. These fossiliferous shales are almost invariably nodular with calcareous ironstone, the nodules generally decreasing in numbers and size along with the marine remains, and disappearing simultaneously with them. The ironstone had an accretive affinity for the calcareous matter. It is probable that these nodules were first formed either upon the sea-bottom (like the manganese nodules of the deep seas), or very little beneath the surface: for the fossils in the nodules are preserved in their original shape; in the shale itself they are flattened by pressure.

The plants in the upper part of these shales are generally mere dark impressions, as if they had been decomposed by drifting through water. Their most remarkable feature is their assortment and their gradual increase in size as the sediments become coarser. In the sandstones above the shales the drift-wood may attain the size of small snags, not unfrequently laid in slanting positions by the current. The upper part of the cycle, when present, is completed by root-beds, &c., with associated sandstones and shales. The flora does not seem (judging from its remains) to have been either rich or varied.

The sections palæontologically most interesting in this district are those of the thick fossiliferous shales above the limestones at Penchford (hard by the ford); Eastnook (Colster Cleugh); Shittleheugh, not far from Otterburn; and above and below the Redesdale Limestone. The Redesdale Ironstone shale (below the limestone) might appear to be an exception to the cyclical order which has been insisted upon as the marked characteristic of the

* In this district these carbonaceous beds of the Upper Limestone Series are not much exposed, and have not been collected from.

Digitized by Google

Upper Limestone Series. It is not really so. It forms a term of a lower cycle, based upon coal, but without any limestone. (*See* section on p. 48.) This section, and that of the complete cycle at Elsdon Mill (Fig. 3, p. 43), and another in Dargues Burn, Redesdale, above the bridge, will repay the most careful study.*

We add some reference to a few of the more specially palæontological features. The Brachiopods of the limestones and shales are now considerably more numerous than the Lamellibranchiata, —23 species as against 16. The Cephalopoda have increased in numbers and still more noticeably in size; and there are no less than 13 species of corals, some of them luxuriant in their growth. The nodular shales are full of corallines (Polyzoa). In the shale above the limestone at Colster Cleugh, Mr. J. Bennie has detected many beautiful specimens of Holothurid plates. In one or more cases these were scattered thickly over single planes in the shale, as if the animals had congregated upon these surfaces in numbers, or as if their delicate remains had been wafted and spread about by light currents. There are one or more limestones abounding in *Saccammina Carteri*, a fossil at one time believed to be limited to the Four-fathom Limestone, one of the higher limestones that does not enter into this district. Fishes are very rare, both as individuals and species. They do not seem to have much frequented the outer seas.

A table of the species of all three fossiliferous formations of the district is subjoined†.

	Lower Tuedian Division. (*Cement Stones.*)	*Carbonaceous Division.*	*Calcareous Division.* (*Upper Limestone Series.*)
	No. of Species.	No. of Species.	No. of Species.
Plants	6	5	Not collected.
Actinozoa	2	1	13
Echinodermata	1	2	4
Annelida	3	—	1
Crustacea:			
Ostracoda	3	7	9
Schizopoda	14	—	—
Trilobita	—	1	1
Arachnida	5	—	—
Polyzoa	—	—	9
Brachiopoda	1	10	23
Lamellibranchiata	4	18	16
Gasteropoda	3	12	12
Cephalopoda	1	1	4
Pisces	7	2	2

* The collections were made in this district chiefly from the bottom limestones of the Series. Collections from every limestone of the Upper Limestone Series have been made in the adjoining district on the south (106 N.E.), to the Memoir on which the reader is referred.

† It is not pretended that these lists are complete. But they are at least to some extent representative.

Digitized by Google

Localities.

REDESDALE LIMESTONE:—

27. Sundaysight Cleugh at road side, N. of Sundaysight.
28. The same, lower down and N.N.W. from Sundaysight.
29. Tarret Burn, foot of Smithy Cleugh.
30. Raven's Cleugh, Raylees Burn, S. of Ravenscleugh Farmhouse.
31. Elsdon Burn, ½ mile N.N.W. of Elsdon Church.
32. The same. Nodular shale above the limestone.
33. Landshot Burn, ¾ mile east of Elsdon Church.
34. Closehead Limestone Quarry, ¾ mile E. of Otterburn Church.
35. The same. Shale above the limestone.
36. Penchford Burn, ½ mile above Penchford, and 2¾ miles N.N.W. of Elsdon.
37. Small Limestone Quarry, ½ mile S. of Wilkwood East, 4 miles W. from Holystone.
38. Limestone quarries, Ballyardley Hill, 1 mile E. of High Rochester. ? Redesdale Limestone.
38A. The same. Shale above the limestone.

REDESDALE IRONSTONE BED:—

39. Sundaysight Cleugh, near roadside, N. from Sundaysight.
40. The same. Lower down and N.W. from Sundaysight.
41. Tarret Burn at foot of Smithy Cleugh.
42. The same. Dark shale at base of Ironstone Bed near the coal.

FOURLAWS LIMESTONE:—

43. Hollinhead Burn, tributary of Tarret Burn, ½ mile S. of Highgreen.
44. Raven's Cleugh, Raylees Burn, ¼ mile from Ravenscleugh Farmhouse.
45. Landshot Burn, near Landshot, ¾ mile E. of Elsdon Church.
46. Elsdon Burn, rather more than ½ mile N.N.W. from Elsdon Church.

HIGHER LIMESTONES, &c.

47. Penchford Burn, at Penchford, 2 miles N.N.E. from Elsdon. Uppermost Limestone of the section.
48. The same. Shale above the limestone. The fossils were derived by washing the shale.
49. Colster Cleugh, 250 yards N. of Eastnook, and 2 miles east of Elsdon Church; dark shale with ironstone nodules, above limestone.
50. The same. Limy shale below the limestone.

Fossils.

		No. of Locality in foregoing List.
Plantæ -	Araucarioxylon Withami, *L. and H.*	*p.*
	Lepidodendron, *sp.* - - -	41
	Stigmaria ficoides, *Brong.* - -	—
	Stems of ferns - - -	—
Foraminifera -	Saccammina Carteri, *Brady* -	*pp.* 50, 51, 58, 65, 66, 90.
Actinozoa -	Alveolites septosa, *Flem.* - -	31, 46
	Amplexus coralloides, *Sby.* -	38
	Aulopora campanulata, *M'Coy* -	50
	Clisiophyllum, *sp.* - - -	37
	Cyathophyllum, *sp.* - - -	28, 30, 47, 49, 50
	Gorgonia lonsdaleiana, *M'Coy* -	48
	Heterophyllia granulata, *Duncan* -	41

Digitized by Google

		No. of Locality in foregoing List.
	Lithostrotion junceum, *Flem.* -	28, 29, 30, 31, 33, 35, 36, 37, 38, 39, 44, 47, 49, 50.
	L. irregulare, *M'Coy* - -	28, 29, 33, 37, 38
	L. m'coyanum, *M. Edw.* -	31, 36, 50
	Monticulipora tumida, *Phil.* -	35
	Monticulipora, *sp.* - -	47, 48, 50
	Palæocoryne, *sp.* - -	48
	Syringopora, *sp.* - - -	30, 31
	Zaphrentis, *sp.* - - -	29, 31, 35, 47, 50
Echinodermata -	Achistrum Nicholsoni, *Eth, junr.*	32
	Archæocidaris, *sp.* - -	49
	,, spine - -	47
	,, small plates -	48
	Poteriocrinus, *sp.* - -	30, 35, 47
	Rhodocrinus, *sp.* - - -	30, 47, 49
	Crinoid ossicles - - -	27, 29, 31, 38
	Holothurid plates* - -	48, 49
Annelida - -	Spirorbis caperatus, *M'Coy* -	48
Crustacea - -	Phillipsia, *sp.* - - -	28, 35, 40, 49
	Trilobite fragment - -	48
	Bairdia Hisingeri, *Mün.* -	48
	B. plebeia, *Reuss* - -	48
	Leperditia, *sp.* - - -	32, 35, 44
	Leperditia? - - -	33, 46
	†Bairdia plebeia, *Reuss, var.* -	48
	B. submucronata? *Jones and Kirkby* - - -	48
	Cythere? cuneola, *J. and K.* -	48, 49
	C.? cornigera, *J. and K.* -	48
	Cytherella valida, *J. K. and Brady* - - - -	48, 49
	C. scrobiculata, *J., K., and B.* -	48
	C. recta, *J., K., and B.* - -	48
	Leperditia Okeni, *Mün.* -	49
Polyzoa - -	Fenestella flabellata, *Phil.* -	49
	F. plebeia, *M'Coy* - -	49
	F. tenuifolia, *Phil.* - -	40
	Fenestella, *sp.* - - -	30, 37, 42, 47, 48
	Glauconome bipinnata, *Phil.* -	49
	G. gracilis, *M'Coy* - -	49
	Polypora verrucosa, *M'Coy* -	48
	Polypora, *sp.* - - -	50
	Rhabdomeson rhombiferum, *Phil.*	47, 49
Brachiopoda -	Athyris Royssii, *Lev.* - -	41
	Athyris, *sp.* - - -	36, 40, 42, 44
	Chonetes laguessiana, *De Kon.* -	35, 47, 49
	Chonetes, *sp.* - - -	41, 48
	Discina nitida, *Phil.* - -	41
	Lingula scotica, *Dav.* - -	32
	Orthis Michelini, *Lev.* - -	41, 49
	O. resupinata, *Mart.* - -	49

* Observed by Mr. James Bennie.

† For the following list of Ostracoda from the nodular shales of Penchford Burn and Colster Cleugh, I am indebted to Mr. James W. Kirkby.

Digitized by Google

		No. of Locality in foregoing List.
	Orthis, *sp.*	47
	Productus giganteus, *Mart.*	28, 29, 30, 31, 32, 33, 38, 41, 45, 47
	P. punctatus, *Mart.*	28, 32
	P. undatus, *Def.*	32
	P. semireticulatus, *Mart.*	27, 40, 41, 45, 49
	P. pustulosus, *Phil.*	*p.* 94 (footnote)
	P. longispinus, *Sby.*	27, 28, 49
	P. youngianus, *Dav.*	41
	P. costatus, *Sby.*	40
	P. llangollensis, *Dav.*	34
	Rhynchonella pugnus? *Mart.*	41, 47
	Spirifera laminosa, *M'Coy*	27, 29, 47
	S. trigonalis, *Mart.*	47, 49
	S. glabra, *Mart.*	40, 41
	Spirifera, *sp.*	48
	Spiriferina cristata, *Schlot.*	27
	Streptorhynchus crenistria, *Phil.*	35, 38, 40, 41, 47, 49
	Streptorhynchus, *sp.*	31
	Strophomena rhomboidalis, *Wilckens*, var. analoga, *Phil.*	27, 35, 39, 49
	Terebratula, *sp.*	29, 41
	Adherent Brachiopods	48
Lamellibranchiata	Astarte, *sp.*	41
	Aviculopecten interstitialis, *Phil.*	41
	A. fimbriatus, *Phil.*	49
	A. docens, *M'Coy*	40
	Aviculopecten, *sp.*	27, 32, 41, 42
	Axinus, *sp.*	40, 41
	Cardiomorpha, *sp.*	32, 41
	Conocardium, *sp.*	47
	Cypricardia, *nov. sp.*?	41
	Edmondia sulcata, *Phil.*	32, 40
	Leda attenuata, *Flem.*	32, 40, 41
	Myalina, *sp.*	32
	Nucula brevirostris, *Phil.*	41
	N. gibbosa, *Flem.*	41
	Nucula, *sp.*	32, 40
	Pinna flexicostata? *M'Coy*	42
	P. flabelliformis, *Mart.*	42
	Pinna, *sp.*	27
	Sanguinolites, near to plicata, *Portl.*	41
	Sanguinolites, *sp.*	27
Gasteropoda	Aclisina elongata, *Flem.*	48
	Loxonema rugifera, *Phil.*	41, 49
	L. sulcatula, *M'Coy*	40
	L. Urei? *Flem.*	48
	Macrocheilus michotianus, *De Kon.*	*p.* 94 (*footnote*)
	Macrocheilus, *sp.*	41, 49
	Murchisonia sulcifera, *Portl.*	42
	Naticopsis, *sp.*	49
	Naticopsis?	41
	Trochus, *sp.*	48
	Turbo, *sp.*	48

Digitized by Google

		No. of Locality in foregoing List.
	Bellerophon Urei, *Flem.* -	40, 41
	B. decussatus, *Flem.* - -	41
	Bellerophon, *sp.* - - -	49
	Dentalium priscum, *Goldf.* -	*p.* 94 (*footnote*)
	Dentalium, *sp.* - - -	40, 41
Cephalopoda -	Cyrtoceras ? - - -	40
	Discites trochlea, *M'Coy* -	*
	Goniatites, *sp.* - - -	35
	Goniatites (young), *sp.* - -	48
	Orthoceras Breynii ? *Mart.* -	35
	Orthoceras, *sp.* - - -	27, 40, 41
Pisces - -	Helodus ? - - - -	38
	Cochliodus, *sp.* - - -	39
	Fish-palate ?† - - -	*p.*

* Found by Mr. Elliot, of Elsdon Mill, in the limestone (probably the Redesdale Limestone) quarried in the fields N.E. of the mill.

† A small collection of fossils from Redesdale, chiefly from Shittleheugh, above Otterburn, was made by the late Mr. George Tate, of Alnwick. They, with the rest of Mr. Tate's Collection, are in the Museum of the Alnwick Mechanics' Institute, and were named by Mr. Robt. Etheridge, F.R.S.

Species.	*Locality.*
Glauconome, *sp.* - - - - -	Shittleheugh
Fenestella, *sp.* - - - - -	,,
Productus semireticulatus, *Mart.* - - -	,,
P. pustulosus, *Phil.* - - - -	,,
Macrocheilus michotianus, *De Kon.* - -	,,
Bellerophon Urei, *Flem.* - - - -	,,
Dentalium priscum, *Goldf.* - - -	Redewater
Dentalium, *sp.* - - - - -	Shittleheugh.

Digitized by Google

CHAPTER VIII.—IGNEOUS ROCKS.

Contemporaneous Igneous Rocks of Old Red Sandstone Age.

The igneous rocks of Old Red Sandstone age consist mainly of purple-tinted porphyrite interstratified with thin beds of ash or ashy sandstone; and appear on the map in six small patches. Two of these, towards the east, belong to the main porphyrite mass of the Cheviot Hills, as shown upon the adjoining map on the north; the others are outlying exposures.* The porphyrite hills are smooth and green, and possess a soil agriculturally richer than that of the tracts of Silurian or Carboniferous. The features or outcrops of the rock are never very continuous. The divisions between them in some cases represent interbedded layers; in others they are perhaps due to the amygdaloidal surfaces between the successive flows; often, however, they are mere joints, changing their direction sharply, and cutting across the beds. The ashes as a rule are poorly stratified, and are not always distinguished easily from the porphyrites. Some isolated exposures and vein-breccias of the latter (*e.g.*, in Lumsdon Burn,) often considerably resemble them; a quasi-brecciated and ashy aspect also is sometimes assumed by the porphyrites directly under the Carboniferous strata, where they are apt to be decomposed and cut up by small cracks and strings of calcite.

Junctions between the porphyrites and the Carboniferous beds are seen in the vicinity of Ridlees. About 250 yards to the south of the house an ochreous knotty limestone is seen resting on purple porphyrite. It overlies it in a manner that makes it hard to say where the one begins and the other ends,—the vertical cracks and a prominent set of joint-planes in the older rock being filled with calcite. A bedded breccia of the porphyrite is seen resting on its parent rock hard by. In Haining Sike again, a mile to the west, there is a freestone, lying almost flat, overlapping and abutting against the small cliffs of an uneven surface of porphyrite. To the east of Ridlees, at Heathery Hill, the junction is a faulted one; several crush-breccias and strings of calcite with a few crystals of galena are seen in the stream lying parallel with the fault on the porphyry side. Further east this fault is very conspicuous in the River Coquet, just beyond the map. Towards the west it becomes wholly obscure; but if it were carried in that direction towards the faults in Byrness

* Mr. J. J. H. Teall has lately (Geol. Mag. dec. II. vol. x, pp. 100, 145, 252, 1883) described the petrological characters of the Cheviot porphyrites with great care and skill; and he concludes that they belong to the three classes of augite-, hypersthene-, and mica-andesites.

Digitized by Google

Hill, as already suggested, it might perhaps account to some extent for the apparent narrowing of the interval between the porphyrites and the Fell Sandstones west of Crigdon Hill.

Contemporaneous Igneous Rocks of Carboniferous Age.

Cottonshope Basalts.—The Cottonshope Basalts are sub-aqueous outflows of igneous matter contemporaneous with deposits of the Lower Carboniferous. They are almost limited, in this Map, to Redesdale. They have been detected in Cottonshope, Spithope, Hungry Law, and on the south side of the Rede near Lumsdon; and at all these points occupy a position at or just above the junction-line between the Lower Freestones and the Cementstone Beds.

In Cottonshope there are two beds of this contemporaneous basalt. The lowermost bed is the thicker of the two, averaging 50 or 60 feet in thickness. It lies just above the base of the cementstones. The upper bed lies a little higher, and averages only about 16 feet thick. Both of them are dull and earthy in texture, dark-grey in colour, sometimes with a tinge of reddish purple, and very amygdaloidal. In the ordinary field-exposures they are intersected by numberless joints and irregular strings of calcite, and are thus so permeated by cracks and hollows that decomposition has advanced far into the heart of the rock. It is difficult even to procure sound hand specimens. For the same reason many copious springs issue at the base of their green outcrops—thrown out by the shales of cementstones below. Within the rock we find abundant fragments of ash, sandstone, shale, and limestone caught up by the melted and moving mass—usually much altered by its heat;—the limestone fragments in a bleached and saccharoidal condition;—the shale changed into hornstone. In the thicker bed of the two there can be seen now and then small exposures of green and purple sandstone, evidently deposited around the irregular knobs of the surface in the intervals between successive flows, and then altered by the heat of the mass above it.

These basaltic outcrops are easily traced; for although their dip is high and variable it is impossible to mistake their smooth green features. As we should expect, they keep to the same horizons. But when the sections at their base are minutely examined slight variations of a few inches or a foot are found to be not uncommon. Thus, in the streamlet that runs in an east and west direction about half a mile south of Cottonshope Head the base of the basalt is clearly seen to cut down through eight or nine inches of a cement stone below it; and there is some suspicion of a greater irregularity still.

The uppermost of these two beds is little seen. It is not known out of Cottonshope. The other can be traced some distance over the watershed on the east; but it too disappears beyond the Roman

Digitized by Google

Road. Small quarries in this rock can be seen near the Outer Golden Pot. It is last seen at the Roman camp east of the road.* The basalt in Spithope, to the west of Cottonshope, is probably a continuation of this lower bed. The few feet of cementstone strata below it are missing, and the basalt rests directly upon the Lower Freestones. Above it there is a peculiar hard siliceous limestone with irregular strings of calcite and occasional fragments of basalt. This bed may have been deposited upon the basalt either while still warm or in the presence of warm springs.

The basalt in Hungry Law appears to be on the same horizon as that in Spithope. It appears very obscurely in this Map, although well seen on the Scottish side of the border; and passing round towards the south (at the head of Outer Stokers Cleugh) it is hard to find room for it at all. Along Ark's Edge and Wooplaw Edge (two miles to the westwards, a little out of this Map), the cementstones cover the freestones directly, and without any sign of the basalt between them.

In the valley of the Rede it is seen in the river 200 yards below the foot of Ramshope Burn, and in a sike south of the river between Ramshope and Lumsdon; and once more, but doubtfully, it is seen on the hill side nearer Coomsdon Burn.

Intrusive Igneous Rocks.

The intrusive igneous rocks of this Map occur chiefly in the form of dykes; a single basaltic sheet caps Lumsdon Law in the extreme north-west. One of the dykes is of pre-carboniferous age; the others (and also the sheet) are all later than the Carboniferous strata into which they have been intruded. Some of them are of Tertiary age, but not, it would seem, all.

Felstone Dyke (*Pre-Carboniferous*).—Within the porphyrite area of Ridlees Burn, in Heathery Hill, there is an intrusive dyke of felstone that has been followed into this Map from the north. It can be traced by a linear feature facing W.N.W., and consists of a purplish-red fine-grained granitoid rock allied to the Cornish elvans. It contains many prominent flakes of black mica and occasional crystals of quartz.

Basaltic Dykes (*Post-Carboniferous*).—The basaltic dykes within the area of this Map are limited to its southern half, except the Acklington Dyke in the north-east corner. That these dykes

---

* This camp has been added to the Map by Mr. C. T. Clough. See *Trans. Tyneside Field Club*, Vol. VIII. p. 25.

Digitized by Google

do not appear in more continuous lines of colour is due partly to their obscuration by surface deposits and partly to the undoubted fact that in many places the igneous matter failed to reach so high as the present level of the surface.

The Elsdon, Otterburn, and High Green Dykes.—These large dykes, which really contain considerably more igneous matter than the Great Whin Sill itself, cross the Map from E.N.E. to W.S.W. The strip which they occupy looks less like the line of a single dyke than a belt of ground liable to linear intrusions. Thus near Elsdon there appears to be three of these dykes with their lines overlapping,—looking upon the map as if they were, one after the other, taking up the running in passing westwards. Near Otterburn and near High Green there are certainly two. From High Green westward these may perhaps diverge; if so, they may reach the Scottish Border at points as far distant from one another as the localities of Kershope Head and Kielder Head. In the area of this map they will be described where they are best seen, passing from east to west.

Near Elsdon a full section of the northernmost of the dykes or lines of dyke is seen in Darden Cleugh. Its south cheek appears in junction with sandstone,—the junction nearly vertical but hading slightly north. The dyke is 150 to 160 feet thick. In Grasslees Burn, nearly opposite North Riding, it can be seen suddenly swelling to twice that thickness and thrusting out a tongue southwards. This line of dyke is seen no more. The second appears in Grasslees Burn a quarter of a mile further to the south,—also on the high road north of Elsdon, where it is 200 feet wide, and in the Elsdon Burn, where it is 145 ft. The third, much decomposed, appears in a cart track near Dunshield, half a mile further south. The second and third seem to occupy lines of fault. Near Otterburn the dykes are seen north of Closehead; in Crossbank Wood; and on the north side of the wood. The basalt appears in imperfect outcrops spheroidally weathered, and there is apparently less of it, for the dykes seem to be thinner. The two dykes near High Green are some distance apart. The more southern of the two is extremely well seen in Red Sike east of High Green, hading slightly northward, and again in the Tarret Burn west of High Green, where it is close beside, and apparently intersects with, a fault containing vein-stuff and traces of lead. This dyke now passes on in a line probably unbroken (though several times concealed) to the western edge of the map, often marked by a grassy ridge mottled with tufts of heather. A fine section of it appears in Black Burn at Gilliehill; it has no hade, and consists of massive plates defined by joints parallel with the cheeks. It shows again at the surface in the courtyard at Highfield Farm; in the Pikes; in the hill called the Cross, where its width is no less than 250 feet; and in the Hawkhope Burn, where it is reduced apparently to little more than a third of that thickness. Beyond Hawkhope Burn it passes under drift. The other and more northern of the High Green Dykes passes straight across

Digitized by Google

the top of Padon Hill, 1,240 feet above the sea, to an old quarry at the road side between High Green and Gib Shield. In the quarry it is much weathered into balls and concentric coats, a structure which has perhaps gained the basaltic dykes of this whole district the name of "Whin Roll" by which they, always supposed to be one and the same, are known among the people.

The microscopic structure of the two dykes near High Green has been described by MR. TEALL.* Of the dyke last-mentioned (the northern) "the original constituents are felspar, pyroxene, ilmenite, apatite, and possibly also olivine. A small quantity of isotropic glass is also present." Two generations of felspar are very apparent. In the other dyke MR. TEALL recognises "felspar, pyroxene, and large plates of an opaque mineral which appears to be ilmenite, also colourless prisms of apatite," and the rock is composed almost entirely of crystalline elements. Both dykes he considers to be "eminently" diabasic and probably affiliated, by their structure at least, to the Whin Sill.

Of the other dykes in this map, by much the most interesting is the *Berry Crag Dyke*, a mile south from Hareshaw Head, where it is imperfectly seen on the hill side at rather more than 1,000 feet above the sea. The north side of this dyke is not seen. Measured from an approximate contact with sandstone (which is rendered decidedly rather quartzitic at its other cheek), there is a thickness of 10 or 12 feet of basalt exposed among the grass. Its range is very nearly east and west. In its lithological character the basalt towards the middle is finely amygdaloidal, with cavities about the size of small shot; nearer the sandstone it becomes extremely fine and passes irregularly into black, blue, and olive-grey tachylite or vitreous basalt. It is worth notice that the vitreous basalt does not occur simply as an outer layer at the cheek of the dyke, nor yet so far as could be detected in any particular pattern, but is irregularly mingled with the fine-grained basalt or anamesite which passes into it. The rock is in consequence very irregular in its fracture.

The *Leonard's Hill Dyke*, or what may locally be so called, appears almost in the line of the Berry Crag Dyke further west. Its direction is about W. 15 N. In the Tarret Burn it is a solid basalt about 10 feet thick. No sign of it can be detected in Cat Cleugh east of Leonard's Hill, though the strata are well exposed. It probably fails to reach the surface.

A narrow dyke is seen below Gilliehill Clints in Tarret Black Burn, beside old coal workings. Its direction is about N.W. and S.E. A thickness of 6 feet of the dyke, much decomposed into a greenish and pale leather-brown soft and chalky looking rock, and with the coal in a burnt condition against its east cheek, can be seen upon the east bank of the stream.

---

* J. J. H TEALL, "Petrological Notes on some North of England Dykes," *Quart. Journ. Geol. Soc.*, Vol. XL., p. 239, 1884. The structure of the dyke nearest the farmhouse is illustrated by a plate (Pl. XIII. Fig. 2.).

Digitized by Google

The dyke at Falstone Burn Head is obscurely seen beside the coal workings. It is apparently 50 or 60 feet wide. This dyke, traceable along a low ridge directed E. 20 S., occupies an important line of fault. On the further side of Hawkhope Burn this same fault where it bounds the underground workings of the Plashetts Coal contained a material which obtained some local celebrity as the "Plashetts Plaster." Its real character is made evident by an unpublished analysis of it by the late REV. HUGH TAYLOR, of Humshaugh.

Analysis of White Clay from Plashetts. March 1851.

	Water	14·481	
Soluble in Acids	CaO	·295	
	MgO	·475	
	KO and NaO	·192	
	Fe_2O_3	traces	
	Al_2O_3	2·392	
	SO_3	·593	
	Cl.	·453	
			18·881
Insoluble in Acids	CaO	·390	
	MgO	·107	
	Fe_2O_3	traces	
	Al_2O_3	37·369	
	SiO_3	43·682	
			81·548
			100·429

It seems to have occurred in a vein with a chalky and pale yellowish appearance, about 3 feet wide; and, as in one or two other cases in the neighbourhood, this decomposed basalt was used as a "whitening" for cleaning silver and as a "rubbing stone" for floors.

Another narrow intrusion of basalt occupies a fault beside Hawkhope Plantation in the bank of Hawkhope Burn. Its width is about 10 feet; its direction about east and west. It is finely amygdaloidal.

The well known Acklington dyke crosses the Map in its extreme north-east corner. It has been quarried near Mavis Hall, and again at a point 200 yards east of Low Burradon.

Intrusive Sheet of Lumsdon Law.

The oval spot of dark red in the north-west corner of the Map, between the Lumsdon and Ramshope Burns, represents a probably intrusive mass of basalt that caps the bluff rounded hill of Lumsdon Law. Although in general appearance boss-like it is probably part of a sheet. It occurs in the Lower Freestone Group. Many small scars of the rock skirt the edge of the hill

Digitized by Google

It is a porphyritic basalt, containing large crystals of plagioclase felspar sometimes three-fourths of an inch in length; occasionally it is amygdaloidal, but rarely to any extent. Weathering out into massive sub-angular blocks, and as a rule devoid of any particularly prominent joints, the soundness of this rock contrasts strongly with the much-rotted contemporaneous traps of the Redesdale district. The slopes of the hill are clad with short sweet grass.

Digitized by Google

CHAPTER IX.—GLACIATION OF THE DISTRICT AND GLACIAL PHENOMENA.

The glacial period has left its mark upon this district in the form of striated rocks, transported boulders,—including some considerable rock-masses,—and boulder clay or till. There is also one considerable group of kames passing by an interesting gradation into moraines, besides several outlying and moraine-shaped knolls of sand and gravel of a kame-like nature.

Glacial Striæ.—The striations upon the rocks, when taken in conjunction with the rest of the evidence, point to a movement of ice in two directions; (1) down the main valleys, or parallel with them; and (2) across the open country from west to east.

1. *Movement along the valleys.*—In the south-western corner of the map there is evidence of a general movement of ice, parallel with the valleys of the North Tyne River and Tarset Burn, which has left its mark as high as Earl's Seat, 800 feet above the North Tyne. Specimens of this striation are preserved at Crawberry Crag on Hawkhope Moor, at 1,000 feet above the sea, having an average direction E. 24 S.; on Earl's Seat, close upon 1,300 feet above the sea, and with the same direction; and south of the Tarset Burn at lower elevations. Glacial striæ upon certain boulders imbedded here and there throughout the till in the valleys have the same direction, and point to a steady continuance of the movement during the formation of the deposit. This glaciation from the W.N.W. was part of a general movement over the watershed on the west side of Peel Fell into the head of North Tynedale.

In the adjoining valley of Redesdale striæ are rare. One set, sufficiently distinct, was observed below the boulder clay upon the limestone of Greenchesters above Otterburn. These scratches pointed E. 20 S., or down the dale; but they were associated with another set pointing in the direction of the upland glaciation to be mentioned directly, *i.e.* about E. 20 N. No striations at all are preserved on the soft rocks of that part of Coquetdale embraced in the map: but there is abundant evidence of ice-movement both down Redesdale and Coquetdale—especially in the striæ at Rothbury, in the distribution of the boulders, and in the fact that the Simonside Hills have been glaciated to their summits, 1,450 feet above the sea.

Thus the purely local evidence of the district is enough of itself to show that there was a thickness of fully 700 feet of ice in North Tynedale and of nearly 1,000 feet in Coquetdale.

2. *Glaciation of the open country.*—The general glaciation of the open country was in a direction a little north of east. By far

Digitized by Google

the larger number of the markings that have been preserved have taken that direction. The best of them, with their locality, elevation, direction, and the number of sets of striæ observed, are given in the following table:—

Upland Glaciation of this District.

Locality.	Number of Observations.	Height above Sea in Feet.	Direction.
Harbottle Hills - -	10	1,000–1,135 -	E. 12 N. (average).
The Beacon - -	3	800–950 -	E. 26 N. (average).
Darden Fell - -	1	1,150 (about) -	E. & W. (about).
Featherwood (1 mile E.N.E. of)	1	1,250 - -	E. 8 N.
Stewart Shield (west of)	1	850 (about) -	E. 3–10 N.
Gib Shield (south of, near Padon Hill)	1	1,100 - -	E. 15 N.
Corsenside Common -	1	1,190 (about) -	E. & W.
Near Wetshaw Hope -	1	920 (about) -	E. 10 N.

This mass of moving ice can have been nothing less than a general ice-sheet, wrapping up the whole district, and covering all the lower elevations of the Cheviot Hills. It seems to have been tapped and drawn out of its way, here and there, so to speak, by the hollows of the valleys, as already shown. If the observer will take his stand on the summit of the Fells near Featherwood, beside the striæ which he will find there at 1,250 feet above the sea (see foregoing table), he may note, looking northwards across the hollow of the Southhope and Ridlees Burns to the Cheviot Hills beyond, how impossible it appears that while the fells were entirely invested the Hills should have escaped. And, from the distribution of boulders, it is clear that they did not. But the topmost Cheviots and some of the head valleys were certainly occupied by one or more local ice-caps. Thus, the hills on the south side of the Rede, north of Blakehope in this Map, show no sign of foreign ice from the west, and were probably on the borders of a cap covering Carter Fell.

Glacier Erosion.—Glacier erosion has left no very conspicuous marks upon this district as compared with many others. What there is is chiefly a smoothing of sandstone surfaces, and a rounding and slight *bevelling* of the front edge of sandstone crags. The escarpments do not seem in any case to owe their existence to the erosion; but neither is there any instance in which any fully developed escarpment has been actually planed down. Fig. 4

Digitized by Google

FIG. 4.

View of a part of Ray Crag, Kirkwhelpington Common, a sandstone escarpment rounded by Glaciation.

illustrates one of the rare cases in which the glaciated outline of a crag has been preserved in anything like perfection; in general they have been scarped afresh by atmospheric action. A few other instances of crag-erosion may be named, *e.g.*, Tod Crag, near Ottercops, Whitefield Hill on Darden Fell, and Staniel Heugh on West Woodburn Common. The last-named appears to have suffered greatly. The sandstone crags of the Simonside Hills have been rounded to the summit (1450 feet).

Transport of Boulders.—The transport and distribution of the boulders follow in the direction of the striæ.

The boulders of far-derived origin are all from the west. In the south-western part of the map small boulders of the grey and reddish granites of Galloway and Crifel passed down the valley of the North Tyne and are sparingly scattered through the boulder-clay on its slopes. They are associated with Silurian grits, small but plentiful, some dull red sandstones, either from the Old Red Sandstone or from the red-stained Carboniferous rocks of East Cumberland and South-west Scotland, some red encrinitic limestones certainly from the latter, and a few pebble-sized stones from the Lake District of Cumberland.* There appears to be no reason why these boulders, though decreasing in number and lessening in size as we pass eastwards, should not be found here and there throughout the whole southern part of the Map. Except in one case, however, they have not been detected, and must have almost died out. The single exception is at the west end of the Simonside Hills in that part of the head valley of the Darden Burn which faces westward at from 700 to 1,000 feet of elevation, like an open cul-de-sac. In this hollow of the Fell Sandstones there is a small sheet of shale-grey till stuck through with glaciated limestones, ironstones, &c., from the nearer country, and a group of travelled boulders of far western origin,—some Crifell granite, numbers of Silurian grits, and one or two pieces of fresh red sandstone certainly from the St. Bees group.†

* Some dull-green stones that might be taken for the last named are certainly felstones from the Screel Hills, west of Criffel.

† This identification is kindly confirmed by my colleague Mr. R. Russell.

Digitized by Google

The boulders from the Cheviot Hills, chiefly consisting of porphyrites, are spread over the greater part of the ground that lies east of the Rede. In Upper Redesdale they are abundant. In Lower Redesdale they have become few and very small, but the more indestructible agates and carnelians which the porphyrites contain are occasionally dug up in the fields and gardens near Otterburn. On the west side of the valley, away from its central hollow, not a fragment has been detected; the last small piece was observed three quarters of a mile up the Wind Burn; east of the valley they perhaps average about 1 per cent. of the boulders in the till, until we reach the bed of the Coquet, and there they can be reckoned in thousands. In the Darden Fell they occur up to 1,250 feet above the sea. These porphyrite boulders are never large and seldom well striated. In the latter respect they resemble the parent rock.

The dispersal of the Cheviot porphyrite may point to the joint action of the ice in the valleys and the ice on the Fells, the valley ice bearing the boulders out from the hills, and the upland ice distributing them eastward. This wide-spread easterly movement extended, as has been already indicated, to the greater part of the uplands in the north of the map. The gritty sandstones at Spithope Head, for instance, were borne eastwards on to the Silurian ground of Harden Edge near Coquet Head; the Silurian greywackes in turn were carried on to the porphyrite at Thirlmoor (north of the map) at about 1,700 feet above the sea.* But, as we have seen, the Fells west of Redesdale Head between Blakehope Burn and the Carter Fell (in 108 S.W.) give no sign of having been overridden by foreign ice. No porphyrite, nor basalt, nor greywacke has been found in the drift upon these hills until we come within a short distance of the Rede, where the ground is comparatively low; nor was any quantity of boulder-drift introduced into the valley from the west anywhere above the Wind Burn and the Rooken, where the till is first met in quantity, clasping, as it were, round the higher ground above. The Carter Fell probably maintained a small ice-cap of its own.

A few perched blocks or ice-moved stones may just be mentioned. There is a perched block on Earl's Seat, 10 feet by 5, at 1,300 feet over the sea. Others at lower elevation are the Crow Stone, the Blue Stone, and the Blue Sow, all not far from Dudlees near High Rochester. All these are of sandstone. The Drake Stone of Harbottle is a gigantic semi-detached block of grit close beside its outcrop, perhaps shifted a few yards by ice, or perhaps by the downward *creep* due to changes of temperature.

A list of the boulders concludes this section of this chapter.

Rocks altogether foreign to the District.

1. Grey granite from Crifel and neighbourhood.
2. Coloured granites from the Galloway District.

* Much greywacke also occurs in the till about halfway between Ridlees and Cottonshope Head, at the head of Haining Sike.

Digitized by Google

3. Permian sandstone of the St. Bees group.
4. Carboniferous sandstones and limestones stained red; from the red-stained beds of E. Cumberland or S. Scotland.
5. Dull green felstones from the Screel Hills.
6. "Green slates and porphyries" from the Lake District.

Rocks included in the District but partly borne from other Areas.

7. Cheviot porphyrites, various shades of dark purple.
8. Brighter red porphyrite from intrusive dykes of the Cheviots.
9. Agates, jaspars, &c.
10. Silurian grits and shales.
11. Porphyritic basalt (Carter Fell, &c.).

Local Rocks which occur as Boulders and are of value as such.

12. Coralline Limestones of the Upper Series, when found on the Fell Sandstones, &c.
13. Ironstone balls of the Upper Series, when found on the Fell Sandstones, &c.
14. Gritty limestones with plant remains, when found on the Upper Limestone Series or Fell Sandstones.
15. Grit boulders from the Fell Sandstones, when found on the Tuedian Beds east of the Coquet.
16. Dark shales and bits of coal driven on to the Fell Sandstones, &c.

Transported Rock-masses.—Besides the ordinary boulders, the trail of which we have thus found to be conformable to the other facts, there are some masses of larger size that have apparently been dragged from their original position and are left lying by themselves. About 200 yards to the west of the shepherd's house of Harbottle Crag, at more than 1,000 feet above the sea, there is a mass of limestone lying buried among the heather. It was probably transported from the limestone-bearing tracts on the W.S.W., and dropped among the grits and red clays of the Fell Sandstones. It is much covered up and not necessarily large; but it was at first mistaken for rock *in situ*.

Several masses of sandstone, of much greater size, lie detached in a similar manner in different parts of Redesdale. Near the foot of Spithope, on Cementstone ground, there are some gigantic masses of freestone, now separated from one another by Hawk Burn and Spithope Burn, but probably at one time united. Tod Law is the name of one; Spithope Head stands upon another; and there is a third, not so well defined, on the east side of Spithope Burn. These masses are mainly composed of angular blocks of freestone of all sizes, or of freestone beds shaken and broken. The most satisfactory hypothesis respecting these sandstone hillocks, lying as they do upon the Cementstones, is to suppose them to be the relics of a glacially transported mass.

Digitized by Google

The Brown Knowe, south of March Sike, Spithope, and another Brown Knowe, west of Cottonshope Farm, are masses apparently of similar character. They lie higher upon the Fells.

*Boulder Clay or Till.**—The Boulder Clay of this district takes its composition and colour from the strata from off which its materials have been scoured. In the districts of the Upper Limestone and Carbonaceous Divisions it is stiff, clayey, and of a carbonaceous-grey shade where there are many shales, passing into a dry and sandy drift where there is much sandstone. Among the Fell Sandstones it can scarcely be called boulder clay at all, being an irregular scattering of sand crowded with angular and sub-angular sandstones and grits, in its general appearance more like moraine-stuff than the boulder-clay which it really represents. The greenish shales of the Cementstone group east of the Coquet pass into an ugly, livid mash of stones and greenish clay. In parts of Southope Burn, again, the drift has taken the reddish tints of the sandstones and shales of the Lower Freestones; and in parts of Ridlees Burn it has the dry and non-argillaceous character which it possesses when compounded chiefly out of Cheviot porphyrite.

All these varieties of Boulder Clay are found to have been spread more or less to the east side (or, in the main valleys, E.S.E. side) of the strata which yielded them. In Holystone Burn, for instance, there will be found exposures of a boulder-clay compounded from the beds of the Upper Limestone Series brought from the west across the Fell Sandstones. In Wilkwood Black Cleugh, again, the carbonaceous-grey till from the Carbonaceous group, is left as if almost in the very process of being driven on to the Fell Sandstones. And in the valley at Harbottle it seems to combine the reddish-brown colour of the porphyry drift that lies higher in the valley with something of the stiffness of the cementstone clays which it rests upon.

The Boulder Clay, where it is thick, rises here and there into ridges, or *drums*, arranged in a direction parallel with the line of the ice movement. Some of the east and west ridges north of Sharperton have been proved (by a borehole in one case on the north side of Ridges Plantation) to be of this character. Another low ridge of the kind lies east and west across the head of Hareshaw Burn, west of Lough Shaw. Many drift ridges in the valley of the North Tyne have a similar arrangement, but their axes are directed along the valley. In the bottom of some of the side valleys, such as Dargues Burn in Redesdale, the Boulder Clay was laid down in an irregular plane, sloping with the hollow, and now bisected by the stream and left in two rudely terrace-like halves, one on each side. In these lateral valleys of the main dales the drift was chiefly deposited upon the western sides of the hollows, these being the sides most sheltered from the ice where it crossed them. These slopes are generally covered with "bent," and will be observed to be very poor in springs.

* These two names are used in this Memoir as synonymous.

Digitized by Google

Kames, Kame-like Mounds, and Moraines.—It is not found possible in this upland district to draw any line between kames and moraines. In by far the best and largest group of glacial mounds in the district there is a complete transition from the one to the other as we ascend the valley in which they lie. This is the east and west valley of Whisker Shield Burn at and above Elsdon. It is probable that the transition might be seen in single sections or adjacent mounds (as is notably the case at Whetstone House just beyond the southern border of the map),* if the sections were only a little better displayed. But with one or two imperfect exceptions the openings into the mounds are all small. Besides the Elsdon Kames there is a sheet of kame-gravel in the valley of the Coquet beside Harbottle. The other gravel heaps or hillocks occur sometimes singly, sometimes in small isolated groups of two and three or five and six. Some of these more isolated mounds are very morainic-looking in their general form, and to some extent, also in their distribution; as for instance, the gravel mounds in the small valleys of Carrick and Featherwood. Others, from the smooth in-bendings of their sinuous flanks are more kame-like, *e.g.*, Whitelee Knowe in Barrow Burn. So also, from its structure as revealed in a tolerably good section, showing tumultuous false-bedding partly laid parallel to the curve of the mound, is the double mound in Tarset Burn, below Smiddywell Rigg. On the other hand, the section of a larger mound lying across the stream in Raylees Burn is distinctly that of a moraine with angular debris. All these mounds are laid beside streams in little valleys. In their per-centage of local and foreign stones they resemble the till of the several localities in which they lie.

Kames and Moraines in Whiskershield Burn. — This largest of the groups stretches from Elsdon up the east and west valley of the Whiskershield Burn for fully 3 miles, *i.e.*, to a point a little beyond the summit-level of its watershed with Fallowlees Burn, a branch of the river Font. At Elsdon,† and in the lower part of the chain, the gravel mounds are large, smooth, and green; higher in the valley they become smaller, more hummocky, and more heathery, and above Eastnook pass into moraine heaps, containing, or perhaps consisting of, a closely-packed debris of angular sandstone. On the south side of Tutehill Moss, just upon the watershed, the mounds have become very confluent, and are still (though little open to inspection) very moraine-like in their materials. In Tute Hill itself, on the north side of the moss, they appear to run together into a sheet, and have passed quite over to the eastern side of the watershed. This interesting transition from kames into moraines has been noticed in parts of the similar east and

---

* *See* Memoir on the Geology of Bellingham and Wark (Sheet 106 N.E.).

† The famous Mote Hills of Elsdon, fine defensive earthworks, probably of some date considerably anterior to the Romans, were originally kames. The sand of which the mounds largely consisted was not difficult to modify into their present shape.

Digitized by Google

west valley of Lisles Burn, a branch-valley of Redesdale lying just south of this Map, especially in a gravel pit at Whetstone House. But in the present instance the transition in passing up the valley seems to be more gradual and much better sustained. It seems strongly if not conclusively to indicate the morainic origin of these kames. It is interesting to note, too, that in these little valleys the ice-shed seems to have lain a little to the east of the parting between the present streams.

The relation of the Elsdon kames to the till below, and to some post-glacial deposits above, is illustrated by two sections in Todholes Sike, near the house.

No. 1.

	Ft.	In.
Alluvium	3	0
Peaty layer	0	9
Alluvium or alluvial underclay	3	6
Peaty earth; stems of roots	0	9
Washy gravel with rootlets	—	
Peat	0	9
Washy gravel	5	0
Laminated brick clay,* deposited thinly over the surface-irregularities of		
Grey or bluish till	—	

No. 2.

	Ft.	In.
Gravelly	3	0
False bedded sand	2	0
Washy gravel	7	0
Laminated clay	2	0
Grey till, top only	1	0

The peaty and alluvial deposits are probably the remains of a small tarn hemmed in by the gravel mounds. Tutehill Moss, at the head of the valley, is the remains of a small lake which owed its irregularity to the same cause.

Moraine at Ravenscleugh.—Between the two valleys of Elsdon and Lisles Burn, with their mingled moraines and kames, there is another east and west valley containing a low mound distinctly (so far as can be seen) morainic. It has been laid across the valley and cut through by the stream (Raylees Burn). A section on its south bank reveals an abundant matrix of sand full of small angular chips of sandstone and some larger angular stones and blocks.

Kame-gravel at Harbottle.—Between the village of Harbottle and the foot of the hills there is a moory plain, generally uneven and stony and becoming rather moundy towards the river in the small fields near the Manse. A section of some six feet of gravel is seen resting on reddish-brown boulder-clay at the top of the river bank near the house. The gravel of the rest of the sheet is little seen; but it distinctly becomes rougher and coarser and contains more grit and less porphyry as it approaches the hills. A similar change takes place in the composition of the boulder clay.

* There is very little laminated glacial clay in this district. A little may be detected, with its stratification upturned at a high angle, in the bed of the Whiskershield Burn, 300 yards below its junction with Landshot Burn; and again 200 yards south of Eastnook.

Digitized by Google

Other Gravel Mounds.—The other gravel mounds in the district may just be mentioned. One small group of mounds includes Tod Law in Carrick Burn, near Wainfordrigg, a large mound of fine gravel with a well-defined sinuous margin, and five or six little knolls along the bank of the stream nearer the house, one of them very round and plump. Another small group is formed by Brown Knowe and three other more or less tumulus-like knolls in Sills Burn, below Featherwood. Two small mounds, Cocklaw Bush and Haremoor Law, lie beside Our Lady's Well at Holystone. A double mound, kamelike in its smooth contour, is cut through lengthwise by a scar of the Tarret Burn half a mile below Smiddywell Rigg. It consists of coarse gravel and current-bedded sand with something of the characteristic tendency to conform in its bedding to the shape of the hill, but resting on 8 or 10 feet of horizontal and laminated sand. Whitelee Knowe is a gravelly hillock with undulating top and sides lying in the hollow of Wilkwood Burn near West Wilkwood. There is also a long gravel mound beside Grasslees Burn in Billsmoor Park, and a very small one, with a gravel pit in it, on the south side of the valley of the Rede west of Monkridge Hall, some distance above the highest gravels of the river. A doubtful moraine mound, consisting apparently of angular sandstones and limestones, lies on the side of the valley about half a mile below Shittleheugh.

Digitized by Google

CHAPTER X.—POST-GLACIAL DEPOSITS.

River Alluvia and Terraces; Peat-mosses, and Buried Forests.

All the larger streams of the district, especially the Rede, North Tyne, Tarset, and Coquet, have their alluvial flats and their terraces of alluvium and gravel. In the North Tyne and the Rede, and in all the streams that drain Carboniferous ground, the alluvium is a sandy loam derived from the sandstones, with an admixture of peat washed from the Fells. In the alluvia of the Coquet the sand is much composed of comminuted porphyrite. The most unstable alluvia of the district are found upon the large flats of the Coquet stretching from Harbottle to Rothbury beyond the Map. These flats are the scene of incessant shiftings of channel; the alluvium is too unstable to permit the growth of trees on any part of them; not a little of it is washed bare even of herbage. The large alluvial tracts of the Rede, near its junction with Elsdon Burn, are liable on a large scale to floods, during which large parts of these low lying spaces become a straggling pond. They are probably the "Marshes" referred to in Froissart's account of the Battle of Otterburn. Further up the river, towards Otterburn itself, they are securely embanked. This part of the Rede is perhaps the site of an old lake.

The remains of former river-flats at higher levels, when partly destroyed and partly preserved, are river terraces. The highest of the river terraces in the Rede and the North Tyne in this Map stand about 40 feet above the present level. In this small part of the Coquet they are in general fewer in number and less in height than in the other streams; but above Linsheeles at the foot of Ridlees Burn, where it enters the Coquet, there are distinct gravel terraces 50 or 60 feet above the stream. The methods of terrace formation can be studied advantageously among the numbers of incipient and imperfect terraces opposite Otterburn. The circumstances tending to their *preservation* can be studied at East Woodburn, where, in making its rapid turn to the S.W. the river is carried by its own centrifugal movement against the opposite side, leaving three tiers of terrace within the angle. In the Tarset Burn, in the nearly straight line of valley between the Highfield Burn and Tarret Burn mouth, the stream pursues its natural course of concentration along the middle line of the valley, leaving terraces here and there on both sides. Something like the "delta terraces" of American authors can be seen at Shittleheugh in Redesdale, at Elsdon further east, and at Hawkhope on the North Tyne. Many of the old river gravels in Redesdale have their boundaries much obscured by the fans of

Digitized by Google

deposit brought down the steep hill-streams. This is particularly the case on the south side of the river between Byrness and Chattlehope.

Of the *peat mosses* of the district, some doubtless consist of *basin peat, i.e.*, old lakes and tarns now filled up with moss, based perhaps on lacustrine marls. Others occupy the site of moist hollows, suitable for vegetable growth and now forming distinct physical areas. The maximum thickness of the peat is not known. It is rare however to see even so much as 10 feet, and it does not probably exceed 12 or 15. Except in a few cases where drainage is carried to excess the mosses are still growing. The peats used for fuel are cut chiefly from drier patches on the edges of some of the larger mosses.

Over the misty heights rising in the west of the Map, towards Monkside and north of it, there is spread much *hill-peat*. It is a ragged cover of peat, stretching both over hill and hollow, chiefly above the 1,250 feet line of contour. Its growth has been fed by the frequent humidity of these upper regions. As a rule the hill peat has an ill-defined margin; and it is often impossible to give more than a rude outline of the peat-covered areas. Between the basin peat and the hill peat there is every gradation.

The buried forests preserved under these peat mosses consist almost entirely of birch, the remains of straggling "shaws" and irregular lines of which extend up to close upon 1,500 feet of elevation, or, as near the west head of Chattlehope Burn, beyond it. Its remains are found almost always at the *bottom* of the peat; the upper part, where peat-growth has been sustained, is without any; but it has by no means formed continuous forest. Well-grown trunks of oak are found at Harbottle Crag shepherd's house, at 1,000 feet of elevation. The modern growth of natural oak where it can be seen west from Holystone dies out, excessively stunted, exactly at 800 feet.

It is the belief in the district that most of the Fells were formerly covered with wood. Beliefs of this kind are apt to be very much strengthened, if not originated, by the preservation of the buried remains; but it is certain that the natural wood of these districts was much richer even within memory.

Digitized by Google

CHAPTER XI. — PHYSICAL HISTORY OF THE DISTRICT. DEVELOPMENT OF THE CONFIGURATION.

It is no part of the intention of this memoir to enter at large into the general physical history of the country. But it is desirable to furnish at least a summary of the physical events to which the geology of the district points us. It is made as short and categorical and as free from theory as possible, and may serve to some extent as a key to the interpretation of the facts of the foregoing chapters.

Summary of Physical Events.

The Wenlock Beds.

Widespread deposits of gritty matter and fine mud in a sea probably of no great depth. Graptolites and a few other marine organisms.

Unconformity.

Long interval.—Strata compressed and folded. Upheaval into a land-surface. Great denudation prior to the Lake-era of the Old Red Sandstone.

The Old Red Sandstone.

Volcanic activity on the borders of one of the lesser lakes of the Old Red Sandstone. Lavas poured out over the upturned edges of the denuded Silurian rocks. Occasional extension of the waters of the lake among the volcanic hills. Lava-flows covering up some of their deposits of red sand.

Unconformity.

Sub-aerial waste. The borders of the extinct volcanic hills carved out into spurs and outlying patches.

The Tuedian Division.

The Tuedian Basement Beds (? partly = Upper Old Red Sandstone).

Formation of local conglomerates by water or ice.

The Lower Freestones.

Slow intermittent subsidence. Gritty sands and coloured muds gathering along the southern flank of Cheviot land. The porphyry Cheviots and Silurian Uplands becoming insulated by depression. Sea opening to the south and west.

Digitized by Google

The Cement Limestones.

Subsidence continued. Deposit of greenish silts and speckled composite sands. Occasional thin growths of swamp and peat on silted-up surfaces, followed by short starts of sudden depression. Frequent influx of the edge of the great limestone sea that lay to the south and west; temporary introduction, thus, of an imperfectly marine fauna and formation of limestones. Some local submarine volcanic action at the beginning of the period.

The Fell Sandstones.

Subsidence continued. Great deposits of quartzose sand and grit spread out by strong currents from the north-east. Porphyry hills still showing above water on the north. Occasional fragments borne from them to the nearer regions. A few alternations of swamp and quiet shallow in the western part of the district.

The Carbonaceous Division.

Subsidence continued, perhaps chiefly by short and sudden jerks. Repeated influx, especially in the western and southern part of the district, of shallow waters full of marine life, but seldom free from sediment and scraps of floating vegetation. Constant siltings-up, by means of peat-tinctured muds and pale sands from some shore lying to the north-east; followed by outspreads of peaty swamp, which sent its roots down among the limestones; succeeded many times over by renewed submergences. A few larger subsidences in the S.W. followed by periods of tranquil sea. The summits of the porphyry hills and most of the southern uplands were now probably about level with the plane of accumulation.

Calcareous Division.

(*Upper Limestone Series.*)

Subsidence continued:—steady periodic descents. Recession of the mean position of the shore-line further to the north and north-east. Great oscillations in its position. Long periods (after each considerable depression, when the shore-line was most distant) of open sea,—tranquil, clear, and often coralline; not probably deep, but teeming with migrations of marine life from the south and south-west. A cycle of deposit after every submergence; the marine life in each case being gradually ousted by a series of coarsening deposits from the nearing shore, and replaced by swamp or peat-covered land when the shore-line had passed further to the south west. Each cycle suddenly terminated by renewed depression.

Digitized by Google

*Hiatus.**

Representing the later Carboniferous ages and the whole of the Secondary era; and terminating with the submergence of the country, perhaps under a Cretaceous sea, and the up-lift of a plain of marine denudation above the sea-level. Probable intrusion of the Whinsill and the diabasic dykes of Highgreen, &c., during this interval.

Tertiary Period of the Great Western Volcanoes and of Sub-aerial Waste.

Subterranean intrusion of Tertiary basaltic dykes into rifts and lines of weakness. Prolonged exposure to sub-aerial waste. Slow excavation of the valleys out of the inclined plane, and sculpture of the features, first on the lower grounds and then on many of the heights.

Glacial Period.

Refrigeration of the country. Permanent ice-caps forming on the hills to the north. Great sheet of ice forced from the west over the plateau and along the flanks of the lower hills up to 1,700 feet, spreading out (and thinning) towards the E.N.E. Striation of the country. Formation of the till, with its striated pavements, drumlins, &c., from the off-scoured materials. [Temporary submergence and re-elevation, but without leaving specific traces.] Moraines and Kames shed from the melting ice.

Recent Period.

Partial re-excavation of the choked valleys nearly along their old lines, and of rocky gorges where these were departed from. Many tarns filled up with basin-peat; straggling forests, slowly destroyed and buried under sheets of hill-peat, &c. Landslips, slow ruin of the face of Crags, &c. Age of human industry.

Development of the Configuration.—The excavation of the valleys out of the inclined plane by rain and rivers, and the sculpture of the surface by rain and runnels, are parts of familiar processes, at work all the country over, which need no explanation here. But there is an interesting *development* in this process of surface-sculpture, and it is worth while to indicate the stage of advancement at which we find it in this district.

The rationale of the development of escarpments is found in the behaviour of the shales. The shales,—soft, full of joints, wasting readily to fine-grained clays, and impervious to water—so that the finest runnels can flow over the surface and carry away the particles resulting from their decomposition—are not able to

* This will be understood to refer only to the gap in the geological succession as it is represented in this single map.

Digitized by Google

resist the atmospheric agencies like the sandstones, and sink at the surface into lines of hollow. Thus, wherever the *differential* waste of the sandstones and shales has recently come into play there is brought into relief a pattern of ridges (sandstones) alternating with furrows (shale) or of steps alternating with terraces. We have illustrations of this, for instance, in the regular little group of escarpment-ridges that slopes down, end on, to the Skirt Burn near Highgreen Pit, looking from Highgreen almost like the bars of a grating; again in the escarpments of which the side runnels have so evidently picked out the configuration on the east slope of Falstone Burn, where the water had only to *run* the upper part of the shales, so to speak, out of the troughs into a gutter placed along their ends;* and on a larger and less obvious scale in the crag-ranges of the Harbottle Hills (where the place of the shales is taken by red clays and thin sandstones),—in the steps and jetties of East Woodburn Common,—and in short, in all the escarpments, crags, terraces, and linear banks of outcrop in the district. The behaviour of the shales and shaly beds comes out in a striking way also as we ascend Redesdale. Above Cottonshope Burn Foot the fells begin to show a loftier and more mountainous appearance; the valleys are deeper; and their sides descend with a long, and straight, and rather concave sweep. Cottonshope (*see* Frontispiece) is the first of these deeper valleys. Hindhope, nearly opposite it, is of the type more usual among the uplying valleys of the district—short, shallow, and made rather rugged-looking by sandstone escarpments. Spithope, Ramshope, Chattlehope, and Redesdale itself above the Dour-hill-end fault, are like Cottonshope. A picturesque gloom hangs in these deeper valleys when the shallow vales of Lower Redesdale are only bleak and misty. The explanation of this difference of configuration is simple. After cutting through the massive grits of the Fells the streams came down upon the *soft and shaly* Cementstone beds, and excavated their courses comparatively readily. Wherever the waste of the shales has been extremely slow, no greater than the waste of the sandstones, there has been none of the differentiation referred to above, and the surface is without the peculiar lineal features of the sandstone outcrops. For a similar reason, there is apt to be little or no development of escarpments where the strata are irregular or broken; disintegration finding it impossible to pick out the softer lines of structure, so that the sandstones and the shales waste slowly together. This can be especially remarked near Emblehope, where prominent scars sink into a mere litter of blocks where they become broken; it explains also the featureleesness of some of the more disturbed tracts of the Map, *e.g.*, the tracts west of Otterburn (especially near High Carrick), and north of Highfield in Tarset.

The differential waste of the surface is brought into play at present almost entirely in the more prominent positions. On the

* This gutter however was not the present channel of Falstone Burn, but a preglacial channel, a little further west than the present one and now buried under drift.

Digitized by Google

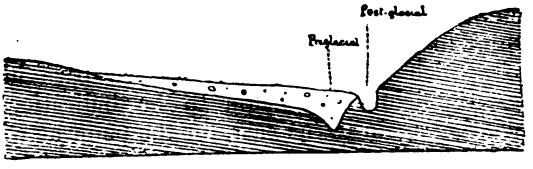
low grounds, and wherever the gradients are low and action sluggish, the general rate of waste being *less than that of the sandstone features*, the projecting lines of sculpture have become effaced. Thus we find that the escarpments of the upper grounds invariably become indistinct as we follow them down towards the valleys. This is partly doubtless the result of glacial erosion and concealment of the features by drift. But it is also a phase of the natural evolution of the configuration by atmospheric agencies. When the tertiary streams first cut their way across the plateau, differential waste naturally came into play on the belts of ground lying nearest to the chief agents of waste, *i.e.*, in the valleys. In after-years, as rain and rivers deepened and widened the valleys, the belts of maximum surface-sculpture moved slowly away from the valleys toward the high grounds, and at the beginning of the glacial period the development had reached its later stage, the heights. Glacial erosion, which only rounded the escarpments, afterwards did much to obliterate the already subdued features, chiefly terraces, that were left nearer the valleys, and the escarpments of the lower grounds were smoothed into subdued terraces and banks. A glance at the glaciated escarpment of Fig. 4, (p. 104) will show what glaciation must have done to obliterate mere terraces.

Preglacial Courses of the Streams.—Buried Channels.—The development of the surface-sculpture, in one or two instances, bears distinct reference, not to the present hollows of the valleys, but to other hollows near them, from which the streams have been excluded by the deposits of the glacial period. These preglacial or buried channels are invariably found to have been more deeply excavated than the existing valleys.

One of the most noticeable facts in the distribution of the till in these districts,—it has been several times referred to in this memoir,—is that it lies thickest on those sheltered sides of the valleys that were subjected to least erosion by the ice. Thus in all the side-valleys of Lower Redesdale and North Tynedale we find the west or south-west slope of the valley distinctly different from the other, barer in aspect, dingier in colour, more featureless in contour, and more gently sloping,—the hollows being levelled up by a sheet of till; while the east side is considerably steeper, and marked by outcrops of rock and different kinds and colours of vegetation. This arrangement of the till is shown in Fig. 5.

FIG. 5.

Sketch-Section (transverse) of a side-valley showing the relative positions of the Pre-glacial and Post-glacial Streams. Direction of glaciation from left to right.



Digitized by Google

The modern streams, where these have deviated from the older valleys, have naturally flowed along the foot of this sloping sheet of till, taking the line where they found it to terminate against the east or driftless side of the valley. Their new ravines thus lie, almost without exception, on the east or south-east side of the buried channels (Fig. 5). It is these new cuts that contain all the best ravine-scenery, the waterfalls, and ledges and fern-fringed bits of precipice or gorge. The old valleys are wide, bare and tame, with a greater breadth of alluvium on the flat and scars of boulder-clay at the bends of the burn. The practised eye can detect the difference almost at a glance.

These facts as to the relation between the modern stream-channels and the ancient ones are new and interesting. They can be illustrated most in accordance with the character of this memoir by entering into some details, which will be given in the most concise way possible, taking the valleys up categorically.

I. *North Tyne and its Tributaries.*

1. *The River North Tyne itself.*—Winds from side to side of its preglacial valley, touching rock at only the extremes of the curves. Falstone Bridge is built on piles driven down into the till.

2. *Hawkhope Burn.*—Masses of drift cover the whole west side of the valley. Outcrops of rock occupy the bed of the stream and the east bank. The rock is lost sight of in ascending Woody Cleugh on the boulder-clay-covered side. The old course is probably near that point.

3. *Falstone Burn.*—Much drift on the west side of the stream. The preglacial course probably lies somewhere near Hawkhope Hill, where there were some borings which met nothing but till. The escarpments on its east side, which are preglacial, seem to bear reference to the old stream-course.

4. *Tarset Burn.*—Almost the whole of the lower part of this stream occupies its old boulder-clay-filled valley, and seldom touches rock. The slopes of its west side are drift covered; those on its east side are rock, marked by occasional outcrops, and (north of Tarret Burn mouth) by coal pits followed down to the water's edge. At Tarret Burn mouth the stream deviates to the east. A few yards below the junction of the Tarret and Tarset Burns there is a foot-bridge built upon till, which was proved by bores to some little depth for a foundation. Sixty yards above this spot the modern stream flows upon the rocky bank of the buried valley. It continues upon rock nearly all the way to Gatehouse Mill. Beside the ruins of the mill it bends west, and re-enters masses of drift, the rock being lost at once. From this point to beyond Highfield Burn the sections are exclusively in drift, which at Waterhead is washed bare in the river bed. Near Highfield there begin to be indications that the stream is deviating again to the east, for the point at which High-

Digitized by Google

field Burn enters upon drift is as much as 600 yards above the junction of the streams. Within a quarter of a mile accordingly, below Keek's Crag, the Tarset Burn is again upon rock; but the deep westward bend before we enter among the sandstones, impure limestones, &c., of Midgy Holes carries it back into deep till. Above Midgy Holes the stream sweeps round to the west, and as at Gatehouse Mill, returns to its old valley, but continues to touch rock at its eastward curves. At Burngrange it branches into three. The eastern branch once more deviates on to the rock of the east bank half a mile above the forks.

5. *Tarret Burn.*—The west side of this valley is drift covered, the east side is bare. The stream is mostly upon rock except for a mile between Smiddy Well Rigg and the foot of Gofton Cleugh where its alluvium is broadest. At the upper part of this reach where it has swerved to the east and flows over rock, a level driven into sandstone in its west bank in search of a lead vein broke into the stony till of the old course. Below Smiddywell Rigg the position of the preglacial channel is more hypothetical, but still sufficiently certain. It seems to cross the present bed of Tarset Burn at a scar of boulder clay above Burnmouth.

6. *Hareshaw Burn.*—The stream flows near the middle of the old valley everywhere above Hareshaw Linn, the picturesque waterfall a little south of this mass, where it runs on the rock of its east bank. The contrast shown by the scenery above and below the Linn is very striking.

II. *Redesdale and its Tributaries.*

1. *Redesdale Main Valley.*—Except between Dykenook and West Woodburn (just beyond the southern edge of the Map) the main part of the Rede down to its junction with the North Tyne is approximately in its old valley, flowing over drift. Descending towards Dykenook the section begins to show rock, and the whole breadth of the clay-filled valley can be detected on the west side of the modern stream and crossed from side to side by the Brig Burn, below Brig farmhouse. This west side of all the lower valley is much more deeply drift-clad than the east side. Hence nothing can be said about the position of the preglacial channels, if such exist, of Brig Burn and Miller Burn.

2. *Elsdon and Whiskershield Burn.*—Elsdon Burn keeps well within its preglacial valley from Whiskershield downwards. Hence, doubtless, the breadth of its alluvial flat.

3. *Otter Burn.*—The Otter Burn runs in deep drift throughout most of the upper part of its course; until, just south of Davyshield, it bends to the east against the rocks which can be traced in its south-east bank. From this point downwards it flows among outcrops of rock. Masses of drift lie to the west.

4. *Durtrees Burn.*—Above Potts Durtrees where the bed of this stream turns west as we ascend, and the alluvium broadens out, there is nothing but drift in a bare-looking valley as far as the

Digitized by Google

gorge at Toft House two miles above. Below Potts Durtrees the stream has evidently trenched through the rock on its south-east bank. The preglacial channel doubtless underlies the drift on its west side.

5. *Dargues Burn.*—The drift of Dargues Burn lies in a sheet, beginning below Dargues Hope, which has been bisected by the boulder-clay-ravine of the stream. It is not until the stream passes against the south-east bank that, about half a mile above Dargues, the clay scars are replaced by rock.

6. *Sills Burn.* — Sills Burn has two considerable tracts of alluvial course in a bare drift-filled valley above and below Sills. The points at which it has encountered rock are certainly points where it has passed to the south-east side of this line of preglacial hollow.

7. *Upper Tributaries of Redesdale.*—The head-valleys of Redesdale, from Cottonshope upwards, are much deeper than any of those that have been described, and contain less drift. Any considerable difference in position between the preglacial rivers and those of the present is not to be expected.

III. *Coquetdale.*

The same may be said to be the case in the tributaries of Coquetdale in this Map. In Barrow Burn and Grasslees Burn glacial deposits distinctly form the *flooring*, so to speak, of the valleys, upon which the stream winds to and fro. Holystone Burn seems to keep to the east of its older channel for the last half mile, where it quits alluvium and takes to rock. But the most interesting change of channel in Coquetdale is at Harbottle, in the main valley. The buried channel there lies parallel with and beside or perhaps underneath the village. The curious loop of the river known as the Devil's Elbow is a scoop in the bank almost at the very point at which the modern gorge leaves the ancient valley, and is doubtless caused by the softness of the deposits that occupy the latter. In the rest of Coquetdale the two courses mainly coincide. Hence its uniformly broad alluvium.

Landslips.—The base of the Fell Sandstones is marked by some gigantic landslips. Such for instance are the Barrow Knocks—a wilderness of detached hummocks and irregular terraces of freestone; the Chambers, on the east side of Barrow Burn; Calf Lee on its west side; Green Holes and Cribs Hole in Spithope; and in Redesdale, Byrness Hill, the Great Dour (Cottonshope), the Stony Holes (Chattlehope), Babswoodhead and Yatehouse Crags, the Countess Holes; the east side of the Windy and How Crags, &c. The slip at the Chambers and perhaps also that at Calf

Digitized by Google

Lee are helped by the dip being down the hill-slope. Another remarkable rock-slip is that at Keyheugh Crag on Darden Fell, where a sudden bend in the dip has caused a sandstone to break away into a great train of blocks that stretch in Titanic confusion for nearly half a mile from the foot of the crag. There is a curious cake of sandstone resting on a dip-slope on the Darden side of Grasslees Burn. A wilderness of shot debris marks its lower edge; the cake itself consists of several acres of yet unbroken rock partially detached along a line of precipitous rift known as High Cove. The dip of the beds is such that it has only to *slope off* a little further to break away bodily; and if the shale below it were converted by the shearing into lubricating material the catastrophe might happen suddenly. This semi-detached mass throws some light on the conditions under which the large transported masses described in Chapter VIII. may have been made ready for removal.

Digitized by Google

CHAPTER XII.—ECONOMIC GEOLOGY AND MINERAL RESOURCES.

Building Stones, Millstones, and Road-metal.—In an economic point of view this district is only remarkable for the abundance of excellent building-stone existing in the freestones and grits of the Carboniferous Formation. There is scarcely an estate in which quarries might not be opened. Even the thin-bedded and close-jointed sandstones can always at least yield small hand-blocks of stone suitable for the building of sheep-folds and "drystone" walls. The building-stone of the more massive freestones is at first often porous, but it is said to "skin over" on exposure to the atmosphere. This is said even of the grits of the Harbottle Hills, many of which appear to the eye very open and absorbent. But for quarrying upon any large scale the district is at present a too outlying one. There are excellent freestone quarries at Burradon (lower part of the Cementstones group); the Harbottle Grits have been quarried at Sealburn Quarry and other places at the edge of the Fells; the sandstone of Crawberry Crag on Hawkhope Moor in the Carbonaceous Division is spoken of as possessing unusual qualities of freeness and durability, and yielded the stone for Falstone Bridge; and in the Upper Limestone Series there are considerable quarries at Hunterlee Hill, &c. But none of these are constantly worked. The pebbly sandstones are sometimes gritty enough for millstones, like the pebbly grit of Millstone Edge beside the gloomy tarn among the Harbottle Hills. Discarded millstones can still be seen lying about the "Edge" in various stages of manufacture. The sand on the shores of the tarn is described as "sharp" and suitable for scythes. The road-metal used in the district is yielded by the limestones and the basalt dykes. The porphyritic basalt of Lumsdon Law is very massive and is suitable for kerbstones, &c., but the hill is of course too outlying. The Cottonshope Basalts are of no economic value, being full of joints and cracks, and decomposed by the permeation of water.

Limestone.—The limestones of the Upper Series are all more or less suitable for the kiln. In a former state of the country, before the valleys were so much laid down into grass, some of them were in frequent use. The lime of Greenchesters limestone especially was in considerable repute across the border. Fifty or sixty years ago, in fact, all the chief limekilns of Redesdale,—Greenchesters Kiln, the Rooken Kilns, and the kilns on the south side of Carter Fell, a little beyond this district, were in full work, sending most of their produce into the neighbouring parts of Scotland. A full analysis of the Redesdale Limestone near East Wilkwood has been given on p. 66, with that of the same limestone a little south of the Map for comparison. At Rooken

Digitized by Google

Kilns this limestone was worked both by quarry and level, and was much esteemed. When the supply was failing a limestone belonging to the Carbonaceous Division was tried beside the Wind Burn, but was found to be of a different and unsatisfactory character. The limestones of the Carbonaceous Division are as a rule gritty and impure; but there are several good beds in the vicinity of Falstone. Thus the Plashetts Dun Limestone and the Piper's Cross Limestone have both yielded quantities of good lime for local use. The thin bands of cementstone in Redesdale have been little tried. The Rothbury Limestones, however, a local development of beds in the north-east corner of the Map, yield good "strong" (*i.e.* magnesian) lime for building purposes, and the kilns at Hetchester are still kept constantly burning. An analysis of the limestone at Newton appears on p. 12.

Ironstone.—A little ironstone has been wrought in the district in times past. Some of the oldest of these are the small workings represented by little heaps of heavy slag met here and there on the uplands. This ironstone appears generally to have been picked out of the scars of shale, or perhaps occasionally out of the boulder clay, doubtless slowly and laboriously, but in sufficient quantities to make a "bloom." The heaps, which in one or two cases are known as "metal hills," may vary in their date from times prior to the Roman Conquest downwards. In 1245, according to Hodgson the county historian, there were iron forges in the district which yielded iron giving an annual rent of 4*l.* 2*s.* (Inq. p.m. Gilbert Umfraville, 29 Henry III.)* The ironstone shales in the Upper Limestone Series,—the only real ironstone beds in the district,—generally lie each above a limestone, and have their ironstone in the form of nodules. The ironstone shale-bed at the base of the series, so much worked at one time at Redesdale and Bellingham further to the south, appears in this map wherever the base-beds are properly seen west of the Rede and south of Elsdon Common. But throughout a great part of the district the nodules are small and light, and probably of little value.

Coal.—Up to the present time the coal seams of the district continue to be in the main sufficient for its own supply. The larger part of the Plashetts Coal-field in this Map, however, may now be considered as practically worked out, and the Hareshaw Head and Brownrigg Coals can be expected to maintain their supply only for a limited period. Looking to the immediate future, the coal at Midgy Holes on the Comb Estate, in Tarset, might seem to give some promise of at least a partial supply for that small dale; some portions of the Elsdon Coal yet remain unworked, though the seam has hitherto always been much drenched with water; there is a deep pit, long in progress, near Penchford, north of Elsdon, which may if the coal improves give a sufficient yield for the supply of Upper Coquetdale;

* Hodgson "History of Northumberland," Vol. I., part II. p. 85.

Digitized by Google

but at present this coal is a mass of little hitches. This practically exhausts the list. There is a solid 3-foot seam at Hepple Woodside which has only so far been dug in crop pits, but it lies within the private grounds of the mansion. In the Ovenstone district the Hepplewoodside and Swindon Coals were abandoned as not further workable, and the same may be said of most of the landsale workings on the fells.*

If we look still further to the future it is a patent fact that none of the seams of the district will repay deep working. Many of them have already yielded nearly as much as can be expected of them at the present cost of labour. Trials will continue to be made with increasing difficulty and expense, and unless some cheaper mode of working small seams is discovered the district must come more and more upon the market for its supply. In the lower parts of the formation, *i.e.* the Fell Sandstones and the rest of the Tuedian Division, search for coal may be regarded as waste of money and time.

Lead.—The few attempts that have been made to find lead ore in workable quantities within this district have as yet entirely failed. Trials have been made, and renewed from time to time during the last 60 or 70 years, in a vein beside the Highgreen basalt dyke in the Tarret Burn, and again at Hollinhead a little further to the east; also in a small vein crossing the Redesdale Limestone at the head of Smithy Cleugh, north of the dyke. These have been rewarded only by a few cabinet specimens of galena and zinc-blende. A few narrow strings of calcite containing strips of galena have been seen crossing the long dip-slope of limestone in Mill Burn, south-east from Elsdon. Strings of calcite and some galena are also associated with the boundary fault of the Cheviot porphyry in Ridlees Burn (Heathery Hill).

Brick and Tile Making.—Small brick and tile works have been temporarily erected at several places, such as near Redshaw south of Elsdon and near Troughend Hall. In these cases the materials are taken from the outcrop of shales at the surface where they are partly decomposed and mingled with drift. Clennel's Tile Works, beside the road from Sharperton to Rothbury, are still in operation. The material is a decomposed green shale of the Cementstone Group (Rothbury Limestones) mingled through glacial agencies with a few stones of sandstone and limestone.

None of the formations entering into the Map contains much fireclay. The few seams that exist in the beds of the Carbonaceous and Upper Limestone Divisions have not been utilised.

Peat—This form of fuel is so abundant in every upland district of the Map that it scarcely needs to be more than mentioned. The large peat mosses are still, as a rule, too soft and wet for utilisa-

* A promising site for a small landsale colliery, however, unless indeed it should be found to be too far up-lying, is the probable outcrop of the Fourlaws and Elsdon Coal on East Woodburn Common, about halfway between Hartside and Wishaw Pike.

Digitized by Google

tion. The peats are generally "cast" from some drier patch of moss upon a slope, or from some bog sufficiently desiccated by draining.

Springs and Mineral Waters.—The district is remarkably well supplied with springs over nearly the whole of its large Carboniferous area. They issue chiefly along the bases of the permeable escarpments, *e.g.*, the outcrops of limestone, sandstone, and the Cottonshope basalts, &c. Perhaps the largest group of springs is found along the foot of the Reedswood Crags, an extremely massive and prominent grit, nearly 100 feet thick, at the head of Tarset Burn. One of these springs may be considered to be a kind of natural curiosity, rising at the surface of a smooth bank in the direct line of descent between two swallow holes only about 30 yards apart. A spring of extreme coldness, greatly in repute among the shepherds, not least because of its unusual elevation, rises beside the escarpment of Oh Me Edge, at about 1,700 feet above the sea. There are several other springs within the district which though not of medicinal qualities possess unusual reputation. Such is Our Lady's Well at Holystone, in which it is averred that Paulinus baptised in 627. Its waters are singularly light and pellucid, and it has hardly even yet lost its monkish reputation for sanctity and curative virtues. As a rule the spring water is very hard. Goitre, which is traced to the influence of hard water infinitesimally mingled with metallic matter, is not uncommon among the people—chiefly, as usual, among the women.

The mineral springs are of two kinds, sulphurous springs or "Sulphur Wells," and chalybeate springs or "Red Wells." One sulphur well issues near a little heap of iron slag beside the stream at Billsmoorfoot. Another, very mild in its tincture of sulphuretted hydrogen, issues among the gravel of the River North Tyne a few yards above Falstone Bridge. Another mild sulphur spring, described as "like Gilsland, but weak," was at one time open on the moor north of Gib Shield, near the footway to Rochester. The Red Wells are much too common even to enumerate. One of the very reddest of them appears beside Black Burn in Corsenside parish, south from Blackstur Lough. The "Silvernut Well" beside Meadowhaugh, south of Otterburn, is a mild chalybeate spring which will be found incessantly at work churning up a comminuted débris of wood mingled with hazle nuts. The nuts are coated with marcasite or iron pyrites at first bright and silvery, then turning to bronze as the mineral tarnishes, and finally disappearing.

Agriculture.—The agricultural interests of this district are almost entirely pastoral. The character of the country has greatly changed in this respect since the earlier part of the century. During the great wars with France the slopes of the main valleys —North Tynedale, Tarset Burn, Redesdale, Elsdon Burn, and Coquetdale were chiefly under tillage, and corn was grown as high as it could be got to ripen. The deep furrows of these times, when the furrow was made to do duty partly as an open

Digitized by Google

drain, can now be seen—especially with slanting sunlight,—crossing the pastures like scores up to 800 and 900 and sometimes as much as 1,000 feet above the sea-level. It is not much more than 50 years since wheat was growing in "Tarset" at an elevation of more than 700 feet, and rye (at Highfield) at 800; some ten years earlier corn crops (with intervals of fallow) occupied most of the ground between Otterburn and Elsdon. But all this is changed —one of the results of free trade and dear labour. The old ploughed fields have been laid down in grass; it is often to be remarked that they make poorer pasture than the fell which has never been cultivated, the soil in these cases having been washed away; here and there they are reverting to heather. All the corn now grown in Redesdale could find storage in the one large empty granary at Girsonsfield.*

The country is now depastured by sheep, chiefly of the Cheviot breed. On some of the grounds where "Cheviots" are bred with least success "black faces" are being tried with something like favour. The Porphyrite hills are fine feeding grounds, sound of surface, covered with verdure, and supporting about two sheep to the acre. They contrast with the duller green herbage of the Silurians and the darker moors of the Carboniferous. Many of these uplying moors, especially those of the Fell Sandstones, support no more than one sheep to two or two-and-a half acres. The area occupied by the beds of the Cementstone group is chiefly "white ground" covered with "bent," including many fescue grasses (*Festuca*), besides of course the ordinary wire bent and broad bent (*Molinea cærulea* and *Nardus stricta*). Of the Fell Sandstones the general cover is heather—sometimes a perfect waste of sandstone blocks—mingled with bent wherever there are superficial deposits of clay. But at Hepple, down in the valley of the Coquet, the sandstone escarpments are among the greenest —and the earliest green—of the valley. The vegetation of the Carbonaceous Beds is a better intermingling of heather and "white ground," and yields excellent alternative feeding. On the Upper Limestone Series there are also some strips of bright verdure, which catch the eye from a great distance, generally dotted with sheep who appreciate the limestone grass quite as much as the geologist who maps the limestones. The basalt dykes where they come to the surface are generally covered with grass mottled with tufts or bushes of heather. One particular field below the road at Troughend, which is upon the basalt dyke there, is, by general consent considered the most fertile in Redesdale.

* The last wheat crops in the district seem to have been grown 35 years ago low down in Elsdon Burn. The crops were good but precarious. Many of the enclosures and probably also some of the "rig and fur" certainly date from some period much earlier than the wars with France, like the rig and fur in North Northumberland, described by Bailey and Culley in 1794 as having been even then "used some centuries since." In the turfing of one of the "fail dykes" of the enclosures S.W. of woodhouses in Coquetdale, the paternal farm of Will Allan, the notorious piper of Northumberland, I found a half-groat of Henry VII., which Mr. Geo. Sims, F.S.A., Scot., tells me was not probably in circulation later than the time of Elizabeth.

Digitized by Google

The western or south-western slopes of most of the smaller valleys being covered with boulder clay are bent-covered "white ground," often very deficient in springs, and apt to be much parched in the height of summer. The peat-bogs and "flows," though soft with aquatic mosses, some of which are useless as pasture, nourish the early-springing cotton-grass, and show the pale April flower of the deer-grass, both of them of great value to the grazier in spring.* Some of the peat-mosses, of course, are soft and dangerous to stock. The Drowning Flow, for example, (between Blakehope and Emblehope), though safe enough to the careful foot, is apt to be very fatal to the sheep. As many as nine of them have been known to founder on the Hindhope side alone, in one day.

Draining is at present making little or no progress, landlords and farmers holding back for more prosperous times. Open-draining has extended to most of the wet slopes and to a few of the peat bogs of the fells; but there are large tracts as yet quite unbroken, including many acres of rocky ground in Middle Redesdale, on the shady side of the valley. It is a fact, however, which has yet to be brought home to the stereotyped improver, that there is such a thing as over-draining;—drying-up the mosses, banishing the damp-loving grasses on which the sheep feed in spring, precipitating the drainage upon the valleys, which are more liable to sudden floods than ever before, and perhaps even lessening the rainfall by desiccating the ground. One or two farmers who have over-drained their farms find sufficient occasion to regret the disappearance of the foul-looking clumps of "sparts" and "stoolbent,"† and the various coarse grasses which gave sustenance to their sheep in the critical seasons of winter and spring, when the grass that looks so much cleaner to the eye is still waiting for April or May.

---

* The cotton grass (*Eriophorum vaginatum*) is commonly known amongst the shepherds as the *moss* or *ling*. The heather *ling* is the *Erica tetralix*.

† *Juncus acutifloris* and *Juncus squarrosus*.

‡ Without citing any one authority for any of the facts of this section, I must acknowledge my indebtedness to many interesting conversations upon agricultural topics with Dr. Robertson of Otterburn and Mr. E. Arkle of High Carrick.

Digitized by Google

APPENDIX I.

BIBLIOGRAPHY.

List of the Chief Publications on the District.

1824. Smith, William.—Geological Map of Northumberland (partly by Prof. J. Phillips).

1836. Phillips, John.—Illustrations of the Geology of Yorkshire. Part II., pp. 210., 214–15, 220–21, 228–31.

1838. Hodgson, John.—History of Northumberland, Part II., Vol. I. (Scenery, agriculture and minerals of Elsdon parish, pp. 83–86; of Corsenside Parish, p. 166).

1857. Raine, Rev. Jas.—A Memoir of the Rev. John Hodgson, Historian of Northumberland. 2 vols. London, 8vo.

1862. Wood, Nicholas.—On the Upper and Lower Beds of Coal in the Counties of Northumberland and Durham (Map of Plashetts Coal-field; scale 1 in=1 mile; and sections). *Trans. N. England Inst. Engineers.* Vol. XI., p. 101. For discussion of this paper *see* p. 196 *et seq.*

1867. Tate, George. A New Flora of Northumberland and Durham. *Trans. Nat. Hist. Soc. Northumberland and Durham.* Vol. II., Chap. I, Geology.

1869. Tate, George.—History of Alnwick. Vol. II., Chap. XXII. Geology, Alnwick. 8vo.

1871. Tate, George.—On the Basaltic Rocks of Northumberland. *Proc. Berwickshire Nats. Field Club.* Vol. VI., p. 197.

1873. Topley, W.—Chapter on "Geology," in "Guide to Rothbury and Upper Coquetdale. Alnwick."

1874. Discussion on Mr. Lebour's paper on the Geology of the Redesdale District. Mr. Lebour on the Harbottle grits. *Trans. N. of England Inst. Engineers.* Vol. XXIII., p. 41.

1876. Brady, H. B.—Carboniferous and Permian Foraminifera. *Palæontograph. Soc.* p. 29. (Foraminifera from Colster Cleugh and Eastnook.)

1876. Lebour, G. A.—On the Larger Divisions of the Carboniferous system in Northumberland. *Trans. N. of England Inst. Engineers.* Vol. XXV., p. 225.

1878. Lebour, G. A.—Outlines of the Geology of Northumberland. 8vo. Newcastle-on-Tyne. 2nd Ed., 1886.

1878. An account of the Strata of Northumberland and Durham as proved by Borings and Sinkings. Vol. I., A.—B. Newcastle-on-Tyne, published by the N. of England Inst. of Min. Engineers.

1879. Lebour, G. A.—Geological Map of Northumberland.

1879. Sladen, Percy.—On *Lepidodiscus Lebouri*, a New Species of Agelacrinitidae from the Carboniferous Series of Northumberland. *Quart. Journ. Geol. Soc.* Vol. XXXV., p. 744.

1879. Lebour, G. A.— On the same, under the name of *Lepidodiscus Squamosus. Ann. Soc. Geol. Belg.*, t. III., p. 21.

1879. Lebour, G. A.—Brief Notes on some of the sections of the Carboniferous Limestone Series of Northumberland published in the first part of "Borings and Sinkings." *Trans. N. of England Inst. Engineers.* Vol. XXVIII.

1880. Howse, Richard.—Note on the Priority of *Archanodon* (*Anodon*) *Jukesii*, Forbes, in the Lower Carboniferous Rocks of N. Northumberland. *Nat. Hist. Trans. Northumberland and Durham.* Vol. VII., p. 376.

1881. Lebour, G. A.—Brief Notes on the Geology of the country round Elsdon. *Proc. Berwicksh. Nat. F. Club.* Vol. IX., p. 595.

Digitized by Google

1881. THOMSON, JAMES.—Native Jasper (the "Reedwater Jasper.") Ibid., p. 537.

1881. An account of the strata of Northumberland, &c., as proved by Borings and Sinkings. Vol. II., C—E.

1882. DE RANCE, C. E.—The Water Supply of England and Wales, its Geology, &c. 8vo. London.

1882. GEIKIE, ARCH.—Carboniferous Rocks of Eskdale and Liddesdale. Nature. Vol. XXV., p. 572.

1883. JONES, T. R.—Notes on the late Mr. George Tate's Specimens of Lower Carboniferous Entomostraca from Berwickshire and Northumberland. *Proc. Berwicksh. Nat. Field Club.* Vol. X., p. 313.

1883. MILLER, H. — "Northumberland." Encyclopædia Britannica. 9th edition. Vol. XVII., p. 574.

1883. MILLER, H.—River-Terracing, its Methods and their Results. *Proc. Roy. Phys. Soc. Edinb.* Vol. VII.

1884. TEALL, J. J. H.—Petrological Notes on some North-of-England Dykes. *Quart. Journ. Geol. Soc.* Vol. XL., p. 209. (High Green Dykes, p. 239-242, with plate XIII.)

1884. LEBOUR, G. A.—Statement respecting the discovery of *Archanodon Jukesii*, in Northumberland. *Nat. Hist. Trans. Northumberland and Durham.* Vol. VIII., p. 31.

1885. An account of the strata of Northumberland, &c., as proved by Borings and Sinkings. Vol. III. F.—K.

1886. LEBOUR, G. A.—Sketch of the Geology of Northumberland. (*Geologists' Association.*)

1886. TEALL, J. J. H.—Petrographical Notes on some of the Igneous Rocks of Northumberland. (*Geologists' Association.*)

Digitized by Google

APPENDIX II.

GLOSSARY OF LOCAL TERMS.

THE BARING - in a quarry, the superficial deposits or other beds that have to be *bared* or removed.
BASTARD - impure.
BRASSY - mingled with iron pyrites.
BULLS - nodules; *e.g.* "iron bulls," ironstone nodules.
CAM - indurated shale.
CASTEN-OOT - thrown out; used with reference to the ordinary débris of pits, but also to natural outcrops and faults. Ex.—*casten-oot to the day*, cropping-out at the surface.
CLINT - a cliff of rock, from Norse *Klint*, a cliff,—in Northumberland generally applied to river cliffs.
CROW SEAMS - thin coal seams of three or four inches thick.
THE DAY - the surface of the ground. Ex.—*cropping out to the day*.
DAY-STONES - loose stones lying weathered upon the surface.
DENE - a wooded dell or ravine.
DODD HILL - in topography, a rounded hill.
DOWK - a broken mass of shale.
EBB - shallow; an expression referring both to the depth of shafts and strata. Ex.—*The coal lies very ebb.*
EDGE - a ridge or rim of ground, generally an escarpment.
FAMP - clayey shale.
FELLS - the confluent hills of the uplands.
FLOW - a peat-bog, generally large and straggling.
FOTHER - a measure of coals,—six bushels.
FREE COAL - coal well jointed and working freely.
FREESTONE - sandstone working easily under the chisel.
GAIR - a strip of verdure on the uplands, generally the outcrop of a limestone.
GASSY - rich in gas. Ex.—a gassy coal.
GIRDLE BEDS - thin bands of sandstone and shale, such as in shafts appear as narrow circles.
GRAINS - the upper branches in a stream.
GREY BEDS - arenaceous shale, generally grey or buff-coloured.
HAUGH - the alluvial flat beside a stream, in Northumberland pronounced *hăff*.
HAZLE - sandstone, generally of a kind too hard to work freely under the chisel.
HOPE - a wide upland valley.
KNOWE - a rounded hillock.
LEVEL-FOREHEAD - the inner end of a drift or level.
LEVEL-SOLE - the floor of the same.
METAL-STONE - hard gritty shale.
MOSS - a peat bog.
MOUTH-GROVES - short levels, generally entering upon the crop of a coal.
MUSHY - mashed up. Ex.—a mushy coal, crushed coal.
ON-PUT - The overlay of beds, &c. above an outcrop. Thus, the *on-put of the hill* and the *onput of the beds*. These are often distinguished from one another.
OUTBURST - outcrop. Ex.—coming to the outburst.
PANELS - the several strata composing a bed of stratified rock, chiefly used with reference to the bands of a limestone.
PLATE - shale.

Digitized by Google

POST - any compact stratum, but generally denoting a bed of compact sandstone from one to six feet thick.
TO *PUT* OUT - to crop out.
TO *PUT* ON - see on-put.
RACE - a range or series. Ex.—*a race of pits.*
RED WATER - chalybeate water depositing limonite or hydrous oxide of iron.
RIGG - a ridge, often an escarpment.
SCARES - streaks or little scars. Ex.—scares of coal.
SHAK-HOLES - in this district applied to soft quaking spots on the moors, generally over a hidden spring.
SIKE - a small branch stream or drain.
SILL - a bed or stratum: Anglo-saxon, *syl* a threshold or anything flat. Ex.—the Whinsill. In the plural it denotes the strata in general. Ex.—*the sills are lying flat.*
A SINKING - a shaft.
SOLIDS - the solid rock as distinguished from soil, moss, drift, &c. Ex.—*the borehole never reached the solids.*
SPLINT COAL - hard stratified coal fracturing in splints. Ex.—*The coal was ploughed up at the outburst in great black splints.*
SULPHUR WELL - a sulphurous spring.
SULPHURY - mingled with iron pyrites.
SUMP - a shallow pit sunk in the bottom of a level, generally the continuation of the main shaft below the working level.
SWAD - impure shaly coal.
SWELLIES - Small basins or arches in the strata produced by undulation.
TENDER - a soft or crushed condition of the strata.
THILL - underclay.
TROUBLE - a fault or hitch, but also any break in the subterranean continuity of a bed.
TUMBLERS - boulders or loose blocks: the "Tumbler Limestone" is a thin limestone above the Great Limestone, chiefly seen in a loose condition.
TUMBLING - loose and out of place.
WATERFALL-HOLES - the common name for swallow-holes.
WHIN - any intractable rock that emits a sharp sound under the hammer. In this district it is generally either basalt or siliceous sandstone.
WHIN ROLL - a general name in North Tynedale for a basalt dyke.
WINNING - a shaft in which coal has been worked or *won.*
WITCH-HOLES - in parts of Coquetdale a name for swallow-holes.

Digitized by Google

APPENDIX III.

BORINGS AND SINKINGS.

(Not included in the text.)

BORINGS on the BIRDHOPE CRAIG ESTATE.

See pp. 26, 27.

(From "Borings and Sinkings," Vol. I., p. 139.)

At the Old Mill, Sills Burn, near the waterside.

	Ft.	In.
Blue grey metal	3	9
COAL	0	8
Blue grey metal	0	9
Whin (6 days)	8	0
Blue grey metal	8	6
Whin (9 days)	3	6
In blue gray metal-stone	18	0
Bored further, viz.:—		
Blue-grey metal stone	5	0
Whitish post with blue scares and water	4	6
Whin (6 days)	1	6
Whitish post mixed with whin (7 days)	6	0
Blueish metal	2	3
Whin (3 days)	0	6
Blue-grey metal	1	8
Post mixed with whin (3 days)	0	9
Blueish grey metal	3	2
COAL, foul	0	5
Blueish grey metal	0	5
COAL	0	6
Blackish blue metal	2	6
COAL	0	6
In lightish blue metal	18	2
	91	0

NOTE.—The mill has now disappeared. It stood beside the stream a little below the ancient ford above High Rochester, near a sheepfold which has probably been built from its materials. The Bore Hole, as I am informed by Mr. John Dixon, of Hopesley House, is known as the Old Mill Well, and is covered by a millstone. The 8-inch coal seam at the top of the section is 25 feet below the outcrop of the 2-feet or "Bush" Seam.

About 560 yards to the N.W. from the (site of the) Old Mill.

		Ft.	In.
Soil	42 ft.	0	9
Stony clay		20	3
Yellowish-brown freestone (loose)		2	8
Blue stony clay		5	4
Mixture whin tumbler		0	10
Blue stony clay		12	2
Yellowish freestone		4	0
Strong white post		14	0

Digitized by Google

	Ft.	In.
Strong white post, with soft yellow partings	9	6
Coal, with water	0	4
Blue metal	6	0
Blueish grey metal	3	4
Coal	0	6
Grey metal	0	5
Coal	0	7
Blue grey metal	5	0
Coal (probable Bush and Bell Shield Seam)	2	1
In blue grey metal	2	3
	90	0

About 140 yards to the south from the last.

	Ft.	In.
Soil	0	9
Blueish stony clay	24	0
Blueish metal stone	2	0
Shivery stone, mixed with clay	6	0
Blueish metal, with yellow scares	9	3
Yellowish freestone, with a strongish feeder of water	4	0
Sandy parting	0	10
Strong whitish freestone	49	2
Coal, foul, with a feeder of water	0	6
Blueish metal	12	10
Blueish grey metal-stone	9	0
Blueish grey metal	2	8
Coal	0	8
Blueish metal	0	8
Coal	0	8
Blueish metal stone	5	0
Darkish grey metal	0	6
Coal	1	11
In grey metal	1	1
	131	6

About 70 yards to the north of the same.

		Ft.	In.
Soil	67 ft.	0	9
Yellowish clay		3	9
Blue stony clay		44	0
Rambly stone, mixed with clay		5	0
Brownish stony clay		13	6
Yellowish metal mixed with *Coal*		0	9
Coal, and black grey metal		0	4
Yellowish metal, mixed with clay		0	5
Yellowish metal, mixed with *Coal*		0	9
Yellowish blue metal		2	9
Blue metal		12	0
Blue grey metal		4	6
Whin (2 days)		0	3
Blue metal		6	0
Whin (4 days)		0	8

Digitized by Google

	Ft.	In.
Blue metal	1	4
Brownish freestone with *coal* pipes and metal partings	9	6
White post, mixed with whin (4 days)	1	6
Blackish sandy parting	0	9
Strong white post	0	6
Coal, foul	0	7
Blackish metal, mixed with *coal*	1	0
Blue grey metal	13	10
Whin (9 days)	1	8
Blue metal stone	1	4
In whin (12 days)	1	3
	128	8

Borings at Hareshawhead.

Section of the Borehole at the South Side of the Cleugh between Hareshaw Head and Ninewell Eyes. 1866–67.

Communicated by Mr. Bart. Armstrong.

	Ft.	In.
Clay	16	0
Dark plate	2	6
Light plate	7	0
Black plate	2	0
Dark plate	2	0
Black plate	0	6
Dark grey stone	0	6
Grey beds	1	1
Band, light colour	0	6
Grey beds	1	1
Dark plate	1	0
Coal	0	3
Dark plate	7	0
Grey beds	3	0
Plate	1	7
Coal	0	3
Black stone	1	6
Top Coal — Ft. 0 In. 8		
Stone — Ft. 0 In. 1½		
Splint Coal — Ft. 0 In. 7½	2	0
Free Coal — Ft. 0 In. 7		
	49	9
Exact depth	50	3

Borehole at the North End of the Outcrop, near the Nine Well Eyes.

Communicated by Mr. B. Armstrong.

	Ft.	In.
Clay	11	6
Plate	3	7
Coal	0	3

Digitized by Google

	Ft.	in.
Plate	0	2
Stone	0	11
Grey layers	1	0
Stone	3	10
Grey layers	2	6
Plate	1	6
Grey layers	3	2
Plate	7	8
Black plate	0	7
Grey layers	2	0
Light sandy plate	8	7
Stone, light and hard	2	9
	49	9

Borings at Ottercops.

(From MS. Collection of "Views and Borings in the Library of the Society of Antiquaries, Newcastle-on-Tyne; Vol. I, p. 247.)

About 280 yards east from the House,* and about 40 yards south from the Outburn (1759).

	Ft.	in.
Soyl and yellow clay	4	6
Blue skamey mettle	12	0
In soft white-grey post with brown skarres and water	7	6
	24	0

600 yards up the Burn from the foregoing, 1759.

	Ft.	in.
Soyl and stoney clay	4	6
Brown and grey post	33	0
Blue grey mettle	12	0
Blue Limestone with water	5	0
Blue and black mettle	28	6
Open Limestone with water	2	0
	85	0

About 400 yards to the east of a hole supposed to be an Old Pitt on the south side of the Burn, about 300 yards from the east boundary, (1759).

	Ft.	in.
Soyl and gravelly clay	2	3
Soft broken brown post	3	9
Brown and grey post, with water at 30 feet from surface	35	6

---

* *See* note on p. 55. The name "Outburn" is now quite unknown.

Digitized by Google

	Ft.	In.
Whin with some white sparkles	4	6
Blue mettle with post girdles	10	3
Coale with water	0	3
Strong blue Limestone or whin	5	6
Blue mettle stone with post girdles	5	0
Strong blue Limestone or whin	3	6
White post with brown skarres and much water	15	0
Strong white post and water	8	0
	100	6

Coal Pits at Elsdon.

("Borings and Sinkings," Vol. 2, pp. 279, 280.)

Section of the Strata of the First Water Level Pit, from the First Coal Pit at Elsdon. Nov. 23, 1753.

(Position unknown.)

	Ft.	in.
Sunk in earth	24	0
Broken post and ramble	6	0
Blue whin	1	6
Blue ramble	9	0
Brown post	6	0
Blue stone	3	0
Strong post with partings	3	0
Black stone	0	7
Coal (*Elsdon and Fourlaws Seam*)	3	0
	56	1

Sunk in a Pit at Elsdon, where Engine was first set by John Liddle and Co.

(Position unknown.)

	Ft.	in.
In clay	21	0
Blue ramble with water	2	0
Whin	1	3
Blue stone	1	9
Strong white post	2	0
Blue ramble	2	6
Strong dun whin	3	0
Blue stone	4	6
Strong white post	3	0
Strong whin	1	6
Grey girdle mixed with whin	2	3
Black metal	0	7
Coal (*Elsdon and Fourlaws Seam*)	3	3
	48	7

Digitized by Google

BORED at ELSDON, March 22nd, 1722–3.

(Position unknown.)

	Ft.	in.
Earth and sand	18	0
Blue metal	1	6
Strong whin	0	9
Grey metal	9	9
Strong whin	1	0
Girdley post	11	3
COAL (*Elsdon and Fourlaws Seam*)	3	4
Grey thill	0	9
	46	4

BORINGS NEAR OTTERBURN.

(From "Borings and Sinkings," Vol. I., pp. 8, 9.)

Boring in Quarry at Allenshead or Allen's Close (Closehead).

	Ft.	in.
Freestone	1	0
Grey metal	6	0
COAL	0	6
Whitish thill with hard beds or nodules	6	2
Blackish metal	9	6
Whitish marl stone	2	10
Whin, greyish and broken	1	6
White marl stone	2	4
Whin dark and hard	0	8
Black stone	2	5
COAL	0	1½
Dark grey stone	2	2
Yellow and green stone, mild	5	6
Yellow freestone, hard	4	6
White freestone	26	0
Yellow freestone, mild, beddy	8	3½
Grey metal	0	3
Whin mostly very hard	2	9
Marl stone with nodules	7	5
Hard dun stone	1	4
Whitish mild stone	5	4
Grey freestone	6	0
Black stone	3	8
COAL, very pure	0	9
White stone, like hitch, darker at bottom	2	0
	109	0

BORE HOLE on the GIBSONSFIELD SIDE, about 15 fathoms below the level of the QUARRY-HOLE.

	Ft.	in.
Clay and sandy gravel	11	0
Broken whin	2	0
Whitish metal	4	6

Digitized by Google

	Ft.	In.
Yellow stone, mostly mild, with some beds of nodules harder and coarser	13	6
Coarse red (rusty red) sandstone	12	0
Yellow freestone, hardish	7	5
Gray metal, soft, with scares of *Coal*	1	9
	52	2

Note.—The quarry or quarry hole referred to is almost certainly a small freestone quarry, situated high on the hill exactly half way between Closehead and Girsonsfield, and about 100 yards from the dyke separating the two farms, in which direction there is an open descent. It is probable that neither of the bore-holes was deep enough to reach the coal. The little quarry is not less than 20 fathoms above it. In "Borings and Sinkings" the quarry is evidently identified with Closehead *limestone* quarry, ¾ mile straight east from Otterburn Church or Chapel of Ease. But there is no part of Girsonsfield which the borer could possibly describe as 15 fathoms below that site.

Borehole north of the Pit Road.

	Ft.	In.
Stony clay	12	0
Hard grey post bed	0	8
Metal. soft, and mixed in colour with some sooty *Coal* on top	18	0
Whin, very hard and sound	0	8
Darkish stone, gritty	4	3
Grey mixture stone, hard	1	6
Hard whin	0	5
Grey stone	2	8
	40	2

Coal Pit at Penchford.

2¾ miles N.N.E. from Elsdon.

Section of the Coal Pit at Penchford.

230 yards N.N.W. from the Ford.

	Ft.	In.
Wood, casing of	60	0
Limestone Grey beds and sandstone Shale	15	0
Limestone	2	6
Shale	30	0
Sandstone	21	0
Coal, 7 in. to 9 in.	0	8
Shale, coarse, like grey beds	6	0
Dark shale, with ironstone nodules and fossils	11	0
Pale shale	1	6
Pale Limestone	3	2
Pale shale	4	8
Dark layer	0	2
Seggar clay	2	8

Digitized by Google

	Ft.	in.
Sandstone	19	6
Coal	0	2
Plate or Seggar	2	8
Sandstone	5	2
Plate, with *Productus reticulatus* in lower part, coarse in upper	6	0
Calcareous grit	1	6
Sandstone	16	0
Plate	5	0
Coal, Elsdon and Fourlaws Seam	3	0
	205	4

Note.—This pit was sunk in 1880–81 on the site of one of the air-shafts connected with an old water-level. This upper part of the section is cased with boarding. The middle part was measured from a swinging bucket as accurately as was found possible. The lower part was taken in the water-level, the bottom of the shaft being at the time still about 8 fathoms from the coal. It has since been completed under new management, but I regret to say that the present owner has seen fit to withhold information. The above section may however be accepted as sufficiently near the truth.

Digitized by Google

INDEX.

A.

Acklington Dyke, 100.
Agate, 9, 18.
Agriculture, 2, 95, 125.
Aid Crag Grit, 47, 48, 51, 53, 63.
Allensclose or Allenshead Colliery, 64, 137.
Analyses; of Rothbury Limestones, 12, 14; of Redesdale Limestone, 66; of Cannel Coal, 36; of "Plashetts Plaster" (basalt), 100.
"Ancient washes," 64.
Anodonta Jukesii, 84.
Anticlines near Closehead, 72.
Ark Edge, 97.
Arkle, E., 127.
Armstrong, B., 46, 134.
„ Joseph, 58.
Ashes, igneous, 95.
Ashy Coals, 33.
Assortment of drifted plant-remains in the shales of the Calcareous Division, 89.

B.

Bagraw, 29, 50.
Bailey and Culley, 126.
Ballyardley Hill; 74; fossils from, 91.
Barrow Burn a pre-glacial valley, 120.
„ Knocks, landslips at, 120.
„ Scar, 11, 82.
„ Scroggs, 11.
Basalt Dykes, 77, 79, 97, 124.
Basement Beds (Carboniferous), 5, 6, 9, 113.
Basin Peat, 112.
Baty, Mr., 54.
Beacon, The, Coquetdale, Fault on south side of, 70; fossil near, 84; glaciation of, 103.
Bellshield Coal, 27, 28, 123.
„ Burn, coal under limestone in, 28.
Belling Burn Limestone, 30, 31.
„ Limestone, 35, 36, 37, 39.
Bellingham, 76.
Bennie, Jas., 62, 90.
Bennettsfield, coal at, 50.
Berry Crag Dyke, 99.
Bewcastle grits, 5.
Billsmoor Park, 23, 24, 60, 110.
Billsmoorfoot, fault at, 71, 72; sulphur spring near, 125.
Birdhope Craig, 26, 27, 132.
Birch woods, buried, 112.
Birky Gill, coal in, 54.
„ Sike, 18.
Black Band, resembling cannel coal, 36.
„ Blakehope, old coal pits near, 28 faulted inlier at, 69.
„ Crag, near High Green, coarse grit of, 47, 48, 51, 53; fault at, 77.
Blackburn Common, 74.
Black Burn (Corsenside), 76, 125.
„ Burn (Sills Burn), coals in, 25; fault in, 70.
„ Burn (Tarset), 29, 35, 75, 98.
„ Linn Burn, Highfield, 39.
„ Stitchel, 57, 65, 73.
Blakehope Burn, inliers in, 10; faulted inlier at head of, 69; fossils, 86.
Blakehope Fell, near Otterburn, 49, 50.
Blackstur Lough, 76, 125.
Blakeman's Law, 65, 69.
Bloomeries, 123.
Blue Sow (boulder), 135.
„ Stone (boulder), 135.
Bore Well, Hareshawhead, 46, 75.
"Borings and Sinkings," 12, 50, 64, 128, 129.
Bottom Limestones of the Calcareous Division, 22, 44, 45, 49, 51, 54, 60, 64, 65, 66, 71, 74, 75, 76, 80.
Boulder clay or Till, 107.
Boundary lines of the Carbonaceous Division, 16, 20, 72.
Brachiopoda and Lamellibranchiata, relative abundance of, in the several formations, 82, 85, 90.
Brady, H. B., 65, 90, 128.
Branshaw, limestone at, 66.
Breccia of porphyrite rock, 95.
Brick and Tile works, 56, 124.
Bridges built on Boulder clay or Till, 118.
Brig Burn, crosses pre-glacial valley of Redesdale, 119.
Brown Knowe, Cottonshope, 107.
„ Featherwood, 110.
„ Spithope, 107.
Brownrigg coal seam, 49, 65, 73, 80, 123.
Building Stones, 122.
Buried Forests, 112.
Buried Valleys, 117.
Burradon, 12, 100.
Bush Coal Seam, 26, 132, 133.
Bushman's Crag, 70.
Byrness Hill, 11, 69, 95, 120.

Digitized by Google

C.

Cadger Bog, 69.
Carbonaceous Division, 5, 20, 85, 114; more marine towards the S.W., 86.
Carboniferous Limestone Sea, 81, 82, 85, 88, 113, 114.
Calcareous Division, 5, 42, 88, 114.
Calciferous Sandstones of Scotland, 82.
Calf Crag, 70.
Calf Lee, 18, 70, 120.
Cannel Coal, 21, 22, 35, 36.
Carrick Coal Seam, 72.
Carrycoats grit, 48.
Carshope Plantation, 32, 79.
Carter Fell, thinning of the Fell Sandstones towards, 18, 19; Ice Cap on, 105; Kilns, 122.
Catcleugh, Redesdale, 10; Cat Cleugh, Tarret Burn, 99; fossils from, 86.
Cement-limestones, 5, 6, 10, 81, 114.
Cement-stones of Scotland, 6.
Cement-stone with *Stigmaria*, 13, 82.
Chalybeate springs, 125.
"Chalk-stone," 23.
Chambers, The, Barrow Burn, 120.
Changes in the beds when followed along the strike, 9, 11, 16, 17, 19, 20, 24, 30, 44, 56, 58, 82, 85.
Chapman, Mr., 36.
Chattlehope, fossils, 83; cleavage in Carboniferous Shale near, 83; valley, 116.
Chattlehope Spout, 19, 69, 85.
Cheviot-derived conglomerates in the Fell Sandstones, 17, 18.
Cheviot Hills, The, in Carboniferous times, 113, 114; agriculturally, 126.
Cheviot sheep, 126.
„ porphyrite, 4, 95; boulders of, 104.
Christie's Bog, 74.
Classification of formations, 3, 5.
Cleavage, in Wenlock Beds, 8; development of, in Carboniferous Shale, 83.
Clennels Tileworks, 124.
Cleugh Head, Greenhaugh Burn, 39.
Closehead, 64, 65, 72, 80, 98, 137, 138; fossils from, 91.
Coal in a limestone band, 22.
Coal Seams, in the Cement-limestone group, 10, 11, 12, 82; in the Fell Sandstones, 16, 19; in the Carbonaceous Division—Donald's Bridge Seam, 22; Swindon and Ovenstone Seam, 22, 23; Hepplewoodside Seam, 22; seam near Whitfield House, 22; near the Crag, 23; in Grasslees Burn, 23, 71; at Billsmoorfoot, 23; in Grasslees Wood, 23; in Billsmoor Park, 24; near North Yardhope, 24; near East Wilkwood, 24; Coals in Sills Burn, 25; the Bush or Bellshield Seams, 26, 27; seam at Dykehead, 27; at Black Blakehope, 28; at Rookenpithouse, 28; at Hillhead, 28; in the Wind Burn, 29; at Kelly's Pike, 29; at Gorlees Crag (Gibshield), 29;
Coal Seams—*cont.*
Shilburnhaugh Seam, 31; Starslee Seam, 31; Belling Crag Seams, 31; seam in Shilling Pot, 32; in Hawkhope Burn, 32; Plashetts Seam, 33–36; seam in Thorneyburn, 35; near Old Hall, 35; in Tarset Black Burn, 35, 36; near Shipley Shields, Tarset, 36; seams at Midgy Holes, Tarset, 36; seam at Watch Crag, Hunter Burn, 38; in Harper Burn, 38; in Coal Cleugh, Hunter Burn, 38; in Sidwood Cleugh, 39; seams in Greenhaugh Burn, 39; seam at Robinson's Groves, Tarret Burn, 40; in Cat Cleugh, Tarret Burn, 40; at Ridley Shield, 40; in Shield Sike, Tarret Black Burn, 40; seams near Blackburnhead, 40; seams at Old Rede's Bridge above Woodburn, 41; seam near Dunshield, Elsdon, 59; Coal seams in the Calcareous Division—The Fourlaws Seam, at Elsdon, 42, 58; at Hareshawhead, 45; at Highgreen, 47; at Brownrigg, 49; at Bennettsfield and Yatesfield, 51; at the Rooken, 52; near Wishaw Pike, 52; on Raylees Fell, 54; in Birky Gill, 54; at Soppit, 58; at Low Carrick, 60; at Landshot, 60; at Penchford, 60; at Otterburn, 63; at Closehead, 64; near East Wilkwood, 66; seam in Smithy Cleugh, Tarret Burn, 48; seam near Hillhead, Elsdon, 56; in Whiskershield Cleugh, 56; at High Carrick, 62; at Toft House, Dudlees, 66.
Coal, absence of workable seams in the Tuedian Division, 124.
Coal Sike, Wilkwood Burn, 24.
„ supply of the district, 124.
Cocklaw Bush, 110.
Coquetdale, in this map mainly a preglacial valley, 120; alluvial terraces in, 111.
Coquet-Larriston Fault, 69.
Cold Law, 74.
Colour of limestones, 55.
Coloured Shales chiefly unfossiliferous, 81.
Colster Cleugh, 78, 89, 90; fossils from, 91.
Comb, The, Tarset, 123.
Concretions and concretionary beds, 14, 25, 44, 61, 65.
Conditions accompanying the deposit of the Tuedian Division, 82, 113; of the Carbonaceous Division, 85, 114; of the Calcareous Division, 88, 114.
Configuration, 12; its development, 115.
Cone-in-cone structure in limestones, 21, 22, 37.
Conglomerate in Wenlock Beds, 7; in the Old Red Sandstone, 8; in the Carboniferous Basement Beds, 9; in the Cement stones, 10; in the Fell Sandstones, 14, 17, 18; in the Carbonaceous Division, 25.

Digitized by Google

Contemporaneous igneous rocks, 95, 96.
Contorted-like structure in Fell Sandstones, 14.
Coomsdon Burn, 10, 81; fossils in, 83.
Corals, 82, 85, 89, 90; not reef builders, 89.
Corallines, 90.
Cornish Elvans, 97.
Corsenside Common, 80; glaciation on, 103.
Cottonshope Basalts, 96, 122; Cottonshope Head, 96; Cottonshope, 10, 116.
Cottonshopeburn Foot, 10, 19, 25, 69.
Countess Crag, 19; Countess Holes, 120.
Crag (Shepherd's House), The, 22, 70.
"Crag Sandstones," 5.
Crawberry Crag, glaciation, 102; building stone, 122.
Cribs Hole, Spithope, landslips at, 120.
Crifel granite (boulders), 104, 105.
Crista Galli, 20.
Cross, The, near Falstone, 98.
Crossbank Wood, Otterburn, 64, 98.
Crow stone, 66, 74, 105.
Crustacean tracks, 20, 22, 37, 60, 63.
Current-bedding in Fell Sandstones, 16, 114; in limestones of the Carbonaceous group, 20.
Cycles of deposition in the Carboniferous strata, 5, 82, 85, 86, 88, 89, 90, 114.
Cyprid bands above the Plashetts Coal, 86.

D.

Darden Burn, 18, 104, 105; Darden Cleugh, 98; Darden Fell, 71, 103; Darden Lough, 72; Darden Pike, 72; Darden fault, 72, 79.
Dargues Burn, 43, 49, 50, 90; drift in, 107; pre-glacial valley of, 120.
Davyshield, 62, 65, 119; Davyshield Common, 73.
Deanhead, 65.
Decomposed Basalt, 99, 100.
Deer Play, 51.
Delta-terraces, 111.
Dendritic markings on limestone, 11.
De Rance, C.E., 129.
Development of the Surface-sculpture, 115.
Devil's Elbow, Coquetdale, 13; pre-glacial valley at, 120.
Diabasic dykes, 99, 115.
Differential waste, 116.
Dislocations and folds, 72.
Dixon, John, 124.
Dodd, The, 30.
Dodd, Great, 39.
Donald's Bridge, 17; Coal Seam, 22.
Dour Hills, 19; Dour-hill-end, 19, 25, 69.
Dove Crag, Harbottle, 18.
Dovetailing of Sandstone beds, 20.
Dowson, Messrs., 18, 58.
Draining, 127.
Drake Stone, near Harbottle, 105.
Driftwood in Sandstone, 89.
Drowning Flow, 127.
Drums or drumlins, 107, 115.
Drusy cavities characteristic of the lower limestones, 11.
Dry Sike, 14, 71.
Dudlees, 65, 66.
Dun Limestone of N. Northumberland identical with the Redesdale Limestone, 5; Dun Limestone of Plashetts, 80, 86.
Dunshield, Elsdon, 42, 59, 78, 98; Coal at, 59 *note*.
Durtrees Burn, pre-glacial valley of, 119.
Dykenook, 76.

E.

Eaker Rigg, 68.
Earl's Seat, glacial striae on, 102; perched block upon, 105.
Earl's Sike, near Catcleugh, 10.
East Cumberland, 5, 104, 106.
East-nook, 56, 62, 78, 89, 109.
East Wilkwood, 65, 66, 91.
„ Woodburn, rocks near, 41; East Woodburn Common, 116; coal on, 124.
Elliot, Mr., of Elsdon Mill, 43, 94.
Ellis Crag, 19, 69.
Elsdon, 57, 58, 59, 78, 98; coal at, 42, 58, 59, 78, 80, 136, 137; delta-terrace at, 111; Elsdon Burn, 78; fossils from, 91; pre-glacial valley of, 119; Elsdon Common, 73; Faults of the Elsdon district, 77; Elsdon Mill, 78, 90; section at, 43.
Emblehope, 79, 116, 127.
Escarpments, 2, 17, 18; development of, 115.
Eskdale in Scotland, 5.
Etheridge, R., 94.

F.

Fairley, Thos., 66.
Fairneycleugh, 78.
Fallowlees Burn, 108.
Falstone, 31, 80; Falstone Burn, 34, 79, 100, 116; fossils in, 86; pre-glacial valley of, 118; Falstone Bridge, 118, 122, 125.
Fans, alluvial, 111, 112.
Farnham, 12, 13.
Faults, 68; faults dying out into folds, 72.
Featherwood, 10, 19, 69; fossils near, 83; glaciation, 103; gravel mounds below, 110.
Fell Sandstones, 4, 5, 6, 14; fossils, 84; conditions of deposition, 114.

Digitized by Google

Felstone dyke, pre-carboniferous, 97.
Fetid Limestones, 20, 27, 29, 59, 78, 85.
Fireclay, 124.
Fish-life of the Carboniferous Limestone sea, more abundant near the shore, 86, 90.
Five Standing Stones, near the Beacon, 70, 84.
Flaggy limestones, 11, 12.
Floods, 111, 127.
Flora of the Tuedian Division, 82; of the Carbonaceous Division, 85; of the Calcareous, 89.
Flows of contemporaneous igneous rock, 95.
Formations, Table of, 3.
Fourlaws Coal, see under Coal Seams; also 76, 77, 78, 79.
Fourlaws Limestone, 42, 44, 45, 47, 48, 49, 50, 52, 53, 54, 57, 60, 64, 66, 76, 77, 78, 91.
Fossiliferous shale above the Plashetts Seam, 34, 86.
Fox Crag, Hawkhope, 79.
Fragments caught up in basalt, 96.

G.

Galena, 77, 95, 124.
Gallow Hill, near Elsdon, 56.
Galloway granite (boulders), 104.
Garret Shield, 51, 62.
Gasteropoda and Lamellibranchiata, relative numbers of, in the formations of the Carboniferous Limestone, 82.
Gatehouse, Tarset, 36, 40, 79.
Geikie, Arch., 129.
Gib Shield, 49, 74, 99; glaciation at, 103; mineral spring near, 125.
Gilliehill Clints, 35, 36, 98, 99.
Girsonsfield, 62, 63, 72, 137, 138; Girsonsfield Burn, 65.
Glaciation of the valleys, 102; of the uplands, 103.
Glacier erosion, 103, 104, 117.
Gofton Cleugh, Tarset, 77, 119.
Goitre, 125.
Golden Pot, 97.
Gorlees Crag, coal at, 29; Gorlees Pike, 74.
Graptolites, 7, 81.
Grasslees, 61, 73; Grasslees Burn, 98; Coal seams in, 23; a pre-glacial valley, 120; Grasslees Mill, 23, 61, 73.
Great Dodd, 49, 75.
„ Dour, 17; landslips at, 120.
„ Moor, 72.
"Great Submergence," 115.
Great Whinsill, 68.
Gravels, glacial, 108–110; alluvial, 111.
Greenchesters, 62, 63, 72, 122; glaciation at, 102.
Greenhaugh Burn, 39, 86.
Green Holes, Spithope, 120.

H.

Habitat, changes of, during the Carboniferous Limestone period, 82, 85, 88.
Haining Sike, 95, 105.
Hallshill, 76.
Harbottle, 74; gravel at, 109; preglacial valley at, 120; Harbottle Crag, 74; transported mass at, 67, 106; Harbottle Hills, 1, 85; glaciation of, 103; crags of, 116; building stones, 122; Harbottle grits, 5; Harbottle Lough, 18, 122.
Harden Edge, 105.
Hare Cairn, 66.
Haremoor Law, 110.
Hareshaw Burn, 107, 119; Hareshaw Dam, limestone near, 41; Hareshaw Fault, 76; Hareshaw Iron Company, 46, 75; Hareshaw Kiln, 46, 77; Hareshawhead, 75, 99; Hareshawhead Coal Seam, 45, 46, 75, 77, 123, 134, 145.
Harper Burn, 38, 79; Harper Crag, 79.
Hartside, 2, 41, 52.
Hawk Burn, Redesdale fossils from, 85.
Hawkhope Burn, 32, 33, 34, 79, 86, 98, 100; preglacial valley of, 118; Hawkhope, delta-terrace at, 111; Hawkhope Hill, fossils from, 86; Hawkhope Moor, 79, 100, 122; Hawkhope Plantation, 79, 100.
Hazle Cleugh, 46, 75.
Heathery Hill, 95, 97, 124.
Hen Cleugh, Redesdale, 8.
Hepple, 126; Hepple Fault, 70; Hepple Kiln, limestone at, 13, 14, 123; fossils in, 83.
Hepplewoodside, coal at, 22, 23, 70, 124.
Heugh, The, near Woodburn, coal at, 41.
High Carrick, 72, 116.
High Cove, Grasslees Burn, 121.
Highfield, 37, 39, 86, 98, 116; Highfield Burn, preglacial channel of, 118.
Highgreen, 47, 53, 75, 77, 91, 98, 124; Highgreen Coal, 47, 76.
High Rochester, coal group at, 26, 27; fossils, 86, 91.
High Spoon Hill, coal at, 66.
Hillhead, Elsdon, 77, 78; coal at, 56.
Hillhouse Clints, Thorney Burn, 80.
Hill Peat, 112.
Hindhope, Scotland, 8; Redesdale, 116, 127.
Hodgson, Rev. John, 62, 123, 128.
Hollinhead, 77, 144; Hollinhead Burn, 47; fossils from, 91.
Holothurid, plates of, 62, 90.
Holystone, 14; fossils, 83; Holystone Burn, 107; pre-glacial valley of, 120.
How Crags, 120.
Howse, Richard, 128.
Hudspath, 57, 62.
Huel Crag, coal at, 26.
Hungry Law, 10.
Hunter Burn, 38.
Hunterlee Hill, 53, 54.

Digitized by Google

I.

Ice-caps, Local, 103, 105, 115.
„ sheet, 103, 115.
„ sheds, local, not quite the same as the present water-partings, 109.
Igneous rocks, of Old Red Sandstone age, 95; of Carboniferous age, 96; Intrusive, 97.
Inner Cleugh, 8.
Interbedded layers in the Cheviot porphyrites, 8, 95.
Iron pyrites associated with the Plashetts Coal, 33.
Iron slag-heaps, 123.
Ironstone, nodular, 35, 44, 56, 89, 123; ironstones called "Lizard stones," 23; ironstone shale of Redesdale, 42, 44, 45, 47, 48, 52, 53, 54, 59, 89, 91, 123.
Ironstone nodules probably formed upon the sea-bottom, 89.

J.

Jaspar and Agate, 9, 18.
Jerks of subsidence, 82, 85, 114.
John Side, Tarret Burn, 86.
Jones, T. Rupert, 129.
Junction of Carboniferous rocks and porphyrites, 95.

K.

Kames, 108; transition into moraines, 108, 109, 115; morainic origin of some, 109, 115.
Kay Heugh, Barrow Scar, 11.
Keenshaw Burn, 23; faults in, 70.
Kelly's Pike, coal at, 24.
Keyheugh Crag, Darden Fell, great rock-slip at, 121.
Kidston, R., 81, 82, 83.
Kiln Rigg, Highgreen, 76.
Kirkby, J. W., 13, 65, 81.
Kirkwhelpington Common, 104.

L.

Lad Cleugh, Black Blakehope, 69.
Laing's Hill, 72.
Lake District, boulders from, 104.
Lamellibranchiata and Brachiopoda, relative proportions of, in the formations of the Carboniferous Limestone, 20, 82, 85.
Laminated clays (glacial), 109.
Landscape marble, 14.
Landslips, 120.
Landshot, 57, 60, 78; Landshot Bu 109; fossils from, 91.
Land surfaces of the Carboniferous, 82.
Larriston Fell sandstones, 5.
Lead, 49, 77, 124.
Lebour, G. A., 82, 84, 85, 128, 129.
Leehouse Rigg, Ottercops, 55.
Leonard's Hill, 99.
Lepidodiscus Lebouri, 41.
Lewisburn, coals of, 30, 31; productal limestone in, 30.
Liddisdale, 6.
Limestone conglomerate, 10, 25.
Limestone Knowe, 74.
Limestones of the Calcareous Division, economic value of, 122; of the Carbonaceous Division, 123; of the Rothbury Limestones, 123.
Linscheeles, 11; Linscheeles Burn, terraces of, 111.
Lisles Burn, 108.
"Lizard Stones," 23.
Long Crag, Kirkwhelpington Common, 55.
Lord's Shaw, 51, 77.
Lough Shaw, 107.
Low Carrick, 78.
Lower Freestones, 4, 6, 10, 113.
Lower Old Red Sandstone, 4, 6, 8, 95, 113.
Lumsdon Burn, 3, 4, 7, 81, 95; Lumsdon Law, 100.

M.

Maconochie, A., 81.
Mavis Hall, 100.
Meadowhaugh, 125.
"Metal Hills," 123.
Midgy Hall, 14, 61, 71.
„ Holes, Tarset Burn, 6, 21, 79, 119, 123.
Migrations of marine life, 114.
Milburn, Mr., Junr., 36.
Mill Burn, near Elsdon, 124.
Miller, H., 129.
Mill-stones, 18, 122.
Millstone Edge, Harbottle, 18, 122.
„ „ Hareshawhead, 75.
Mineral waters, 125.
Mining Institute of the N. of England, "Sinkings and Borings," cited, 12, 50, 64, 128, 129.
Monkridge Hall, 64, 110.
Monkside, 112.
Moraines, 108.
Morainic origin of certain Kames, 107.
Mote Hills of Elsdon, 108.

N.

New Park Plantation, Harbottle, 18.
Newton, near Harbottle, 12, 123.
Ninewell Eyes, 47, 75, 134.

Digitized by Google

Ninety-fathom and Stublick dykes, 68.
North of England Institute of Mining and Mechanical Engineers, 12, 50, 64, 128, 129.
North Riding, near Elsdon, 98.
„ Tyne, Vale of, glaciation of, 102; drums of boulder clay in, 107; alluvial terraces in, 111; pre-glacial valley of, 118.
North Yardhope, 24, 65, 73.

O.

Oak, buried trunks of, 112; present limit of oak woods, 112.
Ochre and ochreous beds, 10, 32, 37, 74.
Oh Me Edge, 2, 125.
Oil shale, 36.
Old Mill well, near High Rochester, 132.
„ ploughed lands, 126.
„ Red Sandstone, Lower, 4, 6, 8, 95, 113; Upper, 5, 9, 113.
Oolitic structure in Tuedian limestone, 14.
Otterburn, 2, 62, 63, 105; Otter Burn, 65; pre-glacial valley of, 119.
Ottercops, 52, 54, 55, 135; Ottercops Burn, 76.
Our Lady's Well, Holystone, 125.
Outliers of the Calcareous Series at the Rooken, 51, 52, 74.
Ovenstone and Swindon Coal Seam, 22, 23, 70, 124.
Over-draining, effects of, 127.

P.

Padon Hills, 47, 75, 99; glaciation of, 103.
Palaeontological cycles, 82, 85, 86, 88, 89.
Passage beds, 16.
Peach, B. N., 8, 83.
Peat mosses, 112; fuel, 124.
Peel Fell, 30, 102.
Penchford, 57, 58, 89, 138; coal at, 44, 73, 123, 139; Penchford Burn, 43, 57, 73; fossils from, 91.
"Pencil Shales" (Silurian), 7.
Perched Blocks, 105.
Periodicity in the deposition of the beds of the Carboniferous Limestone series, 82 *et seq.*
Persistent grit, The, 55, 62, 66, 73.
Phillips, John, 5, 128.
Pikes, The, 98.
Piper's Cross Limestone, 30, 31, 32, 35, 79, 123; fossils from, 86.
Piper Shaws, 23, 70.
Pity Me, Sills Burn, fossils from, 86.
Pit Houses, East Wilkwood, 24; High Green, 76.
Plant-limestones, 13, 20, 24, 30, 31, 37, 39, 40, 41, 51, 59, 82, 85.
Plashetts coal, 31 *et seq.*, 79, 80, 86, 123.
Plashetts Dun Limestone, 31 *et seq.*, 80, 86, 123.
"Plashetts plaster," 33, 79, 100.
Porphyritic Basalt, 101.
Post-glacial Ravines, 118.
Potts Durtrees, 65, 73; pre-glacial valley at, 120.
Pre-glacial courses of the streams, 117.

Q.

Quartz pebbles of unknown origin, 18.
Quarry-sandstones, 18, 122.

R.

Rabbit Crag, near Falstone, 79.
Raechester, 52, 54, 55.
Raine, Rev. Jas., 128.
Ralph's Cleugh, 24; coal in, 28; fossils in, 86.
Ramsay Cleugh, coal in, 24; Ramsay Burn, 74.
Ramshope, 8, 9, 68, 116; Ramshope Burn, 97.
Rattenraw, 49; Rattenraw Burn, 50, 80.
Raven's Cleugh, 54, 77, 78; fossils from, 91; moraine at, 109.
Raven's Knowe, 69.
Raw, The, 60.
Ray Crag, Kirkwhelpington Common, 55; glaciation of, 104.
Raylees, 52, 77; Raylees Burn, 91.
Red clays or shales, 4, 13, 16, 17, 19; unfossiliferous, 84.
Red Cleugh, near Catcleugh, 10.
„ sandstones in the Carboniferous Limestone Series, 4, 10, 11, 16, 19, 48, 63.
Red Sike, Highgreen, 77, 98.
"Red Wells," 125.
Redesdale, general succession of strata in, 6; as affected by the Dour-hill-end Fault, 19, 69; river-terraces in, 111; glaciation of, 102; configuration of, 116; pre-glacial valley of, 119.
Redesdale Limestone and Redesdale Ironstone Bed, 42, 44, 45, 47, 48, 49, 52, 53, 54, 57, 58, 64, 65, 66, 73, 79, 89, 122, 123; fossils, 91.
"Redewater Jaspers," The, 9, 105.
Redshaw, near Elsdon, 56, 124.
Reedswood Crag, coal under, 38, 69, 125.
Re-formed Silurian grit, 7, 16, 19.
Rhodes, J., 81.
Ridges Plantation, near Sharperton, 107.
Ridlees, 11, 95; Ridlees Cairn, 16, 19; Ridlees Burn, river-terraces in, 111; strings of calcite with galena in, 124.

Digitized by Google

Ridley Crag, 67, 74.
„ Shield, coal at, 40, 75.
Rig-and-fur, old ploughing, 126.
Rigend Burn, 69.
Rimpside, 57, 61; Rimpside Burn, 71.
Ripplemark in Limestones, 20, 26.
River-terraces, 111.
Road-metal, 122.
Rob Roy's Cave, 17.
Robertson, Dr. E. C., 127.
Robson, Michael, 32, 48, 80.
Rochester, 24; Rochester Common, 74.
Rooken, The, coal at, 52, 74; limekilns at, 52, 122.
Rookenpit house, coal at, 28; fault near, 79.
Rothbury Grits, 6.
„ *Limestones*, 5, 11, *et seq.*; 61, 83, 114, 123.
Rothbury, glaciation at, 102.
Russell, R., 103.

S.

Saccammina Carteri, 50, 51, 58, 65, 66, 90.
St. Bees Sandstone (boulders of), 104.
Scary Cleugh, Ramshope, 8.
Schizopod Crustacea, 82, 84.
Schorl in conglomerates of the Fell Sandstones, 17, 18.
Scorpions, 82, 84.
Screel Hills, boulders from the, 104.
Scremerston Beds, 4, 20.
Sea of the Carboniferous Limestone ages, 81, 85, 88, 113, 114.
Sealburn Quarry, 122.
Seven Pikes, 51.
Shales, their part in the formation of escarpments, 115, 116.
Sharman, G., 81.
Sharperton, 13, 107; fossils, 83.
Shield Sike, 74.
Shilburnhaugh, coal seam, 31, 32, 86.
Shilling Pot, coal at, 32.
Shipley Shields, coal at, 36.
Shittleheugh, 62, 63, 89, 94; mound near, 110; delta terrace at, 111.
Sidwood Cleugh, coal, &c. in, 39.
Sills Burn, 10; coals in, 25; fossils, 83, 86; pre-glacial valley of, 120; borings in, 132.
Sills Black Burn, 70.
Silurian Rocks, 3, 6, 7, 68; fossils of the, 81; boulders from, 104.
Silvernut Well, 125.
Skirt Burn, 116.
Simonside Grits, 5.
Simonside Hills, glaciated to their summits, 102, 104.
Sims, George, 126.
Sladen, Percy, 41, 128.
Slatyford, 80.
Smiddywell Rigg, 48, 75; kame near, 110; pre-glacial valley at, 119.
Smith, William, 5, 128.
Smithy Cleugh, 48, 76, 124, fossils from, 91.
Snags in sandstones, 89.
Soppit, 57, 65, 80; coal at, 58, 59.
Southope Burn, 11, 14, 103.
Spithope, 97, 106, 116; Spithope Burn, 10, 68, 81, 106; Spithope Head, boulders from, 105; transported mass at, 106; fossils, 83.
Springs, 96; fewness of, on the drift-covered side of valleys, 107, 127; mineral waters, 125.
Stained rocks, Silurian, 7; Carboniferous (boulders), 104.
Staniel Heugh, glacier erosion of, 104.
Starslee, coal at, 31.
Steng Cross, 54.
Step faults, 37.
Stewartshield, glaciation at, 103; Stewartshield Burn, 66, 74.
Stigmarian limestones, 13, 20, 23, 27, 30, 31, 39, 43, 51, 59, 70, 78, 80, 82, 85, 88.
Stirks Cleugh, near Bellingham, 36.
Stoker's Cleugh, 97.
"Stone dykes," 64.
Stony Holes, Chattlehope, 120.
Striated pavements, 102, 115.
Strike, changes in the strata when followed along their, 9, 11, 16, 17, 19, 20, 24, 30, 44, 56, 58, 82, 85.
Stublick and Ninety-Fathom dykes, 68.
Subsidences accompanying the deposition of the Lower Tuedian beds, 82, 114; of the Carbonaceous Division, 85, 114; of the Calcareous Division, 88, 114.
Successive lava-flows, 95, 96.
"Sulphur Wells," 125.
Summary of fossil lists, Tuedian, 82; Carbonaceous Division, 86; Calcareous Division, 90; Summary of geological events, 113, *et seq.*
Sundaysight, 47, 75; Sundaysight Cleugh, 48, 75, 77; fossils from, 91.
Surface-sculpture, 1, 2, 115.
Swarbeck, C. Mc, 12, 66.
Swindon and Ovenstone Coal Seam, 22, 23, 70, 124; Swindon Fault, 14, 15, 16, 22, 61, 65, 71; Swindon Burn, 14, 22, 71.

T.

Table of Formations, 3.
Tachylite, 99.
Tarns, hemmed in by kames, 109; sites of ancient, 112.
Tarret Burn, 37, 39, 40, 47, 48, 49, 74, 75, 77; pre-glacial valley of, 119.
Tarset Burn, 36, 39; alluvial terraces of, 111; pre-glacial course of, 118.
Tate, George, 5, 94, 128.
Taylor, Rev. Hugh, 33, 34, 100.
Taylor, John, 34.
Taylor, T. J., 34, 46, 58, 59.
Teall, J. J. H., 95, 99, 129.
Terminal Curvature, 8.

Digitized by Google

Terraces; alluvial, 111; of outcrop, 116, 117.
Tertiary Basaltic dykes, 68, 115.
Thirlmoor, 9; Silurian boulders on, 105.
Thomson, A. C., 36.
Thomson, James, 129.
Thorney Burn, coal in, 35, 80; fault in, 80.
Till, 107; striation *in situ* of boulders imbedded in, 102; varies according to the formation on which it rests, 107; distribution in the valleys, 107, 117.
Tod Crag and Tod Knowe, east of Elsdon parish, 62, 78.
Tod Crag, near Ottercops, glacier erosion of, 104.
Tod Law, Carrick Burn, 110.
Tod Law, Spithope Burn, 106.
Todholes, 52, 56, 109.
Tofts, near Troughend, 51; Tofts Burn, 72, 80.
Toft House, Dudlees, coal at, 66.
Topley, W., 23, 128.
Tourmaline in Fell Sandstone Conglomerate, 18.
Transition from Kames to Moraines, 107.
Transported Rock-masses, 106, 121.
Traquair, Dr., 37, 82.
Troughend, 49, 51, 126; Troughend Common, 72.
Tuedian Beds, 4, 5, 9; fossils of the, 81; conditions of the period, 82, 113.
Tuedian Grits, 5.
Tweed Beds, 5.
Type-sections of the Carbonaceous Division, 21; of the Calcareous Division, 43.

U.

Unconformities, 6, 9, 95, 113.
Upland-glaciation, 103, 105.
Upper Old Red Sandstone, 5, 9, 113.

V.

Valleys, general direction of, 1.
Valley-glaciation, 102, 105.
Vegetation, of the Porphyrite Hills, 2, 95, 126; of the Silurians, 126; of the Cementstones, 126; of the Fell Sandstones, 1, 2, 126; of the Carbonaceous Beds, 2, 126; of the Calcareous Divisicn, 2, 126.
Vein-stuff near Chattlehope Spout, 69; vein at Highgreen, 124; veins (strings) near Ridlees, 95; near Elsdon, 124.
Vitreous basalt, 99.
Volcanic action, 113, 114.

W.

Wainfordrigg, 110.
Walters, H., 82.
Watch Crags, Hunter Burn, 38, 79.
Waterhead, Tarset, 118.
Wenlock Beds, 3, 7, 113; fossils, 7, 81.
West Edge, 10.
West Wilkwood Sike, 18.
Wetshaw Hope, glaciation near, 103.
Whaup Moss, 55, 76.
Wheat, at one time grown in the district, 126.
Whetstone House, 109.
"Whin Roll," 99, 131.
Whinsill, the Great, 98, 99, 115.
Whitefield Burn, 14, 71; fossils, 83; Whitefield House, coal near, 22.
Whitefield Hill, glacier erosion of, 104.
"White ground," 1, 126, 127.
Whiteheugh Crag, on Comb Moor, 79.
Whitelee Knowe, Barrow Burn, 108.
Whitelee, Redesdale, 6.
Whiskershield Burn, 56, 78; kames and moraines in, 108; pre-glacial valley of, 119; Whiskershield Cleugh, coal in, 56.
Wilkwood, East, coals at, 24, 66, 73; fossils from near, 91; Wilkwood Black Cleugh, 17, 18, 107.
Wilson, J. S. Grant-, 14.
Wind Burn, coals in, 29; drift in, 105.
Windy Crag, 19, 120.
Windy Gyle, 9.
Wishaw and Wishaw Pike, 52, 53, 54, 76.
Witch Holes, 61.
Wood, Nicholas, 128.
Woodburn Common, East, 53.
Woods, destruction of the natural, 2.
Wolf Crag, 55, 76.
Wooplaw Edge, 97.
"Wormtracks," 20, 22, 42, 60, 63.
"Wormtracked" limestones, 20.

Y.

Yatehouse Crags, 120.
Yatesfield, 50; coal near, 51, 65, 73.
Yearning Crag, near Harbottle, 85.

Z.

Zinc-blende, 124.

Digitized by Google

LONDON: Printed by EYRE and SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.
[10025.—500.—12/87.]

Digitized by Google

GENERAL MEMOIRS OF THE GEOLOGICAL SURVEY—*continued.*

The WEALD (PARTS of the COUNTIES of KENT, SURREY, SUSSEX, and HANTS). By W. TOPLEY. 17*s.* 6*d.*
The TRIASSIC and PERMIAN ROCKS of the MIDLAND COUNTIES of ENGLAND. By E. HULL. 5*s.*
The FENLAND. By S. B. J. SKERTCHLY. 36*s.* 6*d.*
The MANUFACTURE of GUN FLINTS. By S. B. J. SKERTCHLY. 16*s.*
The SUPERFICIAL DEPOSITS of SOUTH-WEST LANCASHIRE. By C. E. DE RANCE. 10*s.* 6*d.*
The CARBONIFEROUS LIMESTONE, YOREDALE ROCKS and MILLSTONE GRIT of N. DERBYSHIRE. By A. H. GREEN, DR. C. LE NEVE FOSTER, and J. R. DAKYNS. (2nd Ed. in preparation.)
The BURNLEY COAL FIELD. By E. HULL, J. R. DAKYNS, R. H. TIDDEMAN, J. C. WARD, W. GUNN, and C. E. DE RANCE. 12*s.*
The YORKSHIRE COALFIELD. By A. H. GREEN, J. R. DAKYNS, J. C. WARD, C. FOX-STRANGWAYS, W. H. DALTON, R. RUSSELL, and T. V. HOLMES. 42*s.*
The EAST SOMERSET and BRISTOL COALFIELDS. By H. B. WOODWARD. 18*s.*
The SOUTH STAFFORDSHIRE COAL-FIELD. By J. B. JUKES. (3rd Edit.) (*Out of print.*) 2*s.* 6*d.*
The WARWICKSHIRE COAL-FIELD. By H. H. HOWELL. 1*s.* 6*d.*
The LEICESTERSHIRE COAL-FIELD. By EDWARD HULL. 3*s.*
ERUPTIVE ROCKS of BRENT TOR. By F. RUTLEY. 15*s.* 6*d.*
FELSITIC LAVAS of ENGLAND and WALES. By F. RUTLEY. 9*d.*
HOLDERNESS. By C. REID. 4*s.*
BRITISH ORGANIC REMAINS. DECADES I. to XIII., with 10 Plates each. Price 4*s.* 6*d.* each 4to; 2*s.* 6*d.* each 8vo.
MONOGRAPH I. On the Genus PTERYGOTUS. By T. H. HUXLEY, and J. W. SALTER. 7*s.*
MONOGRAPH II. On the Structure of the BELEMNITIDÆ. By T. H. HUXLEY. 2*s.* 6*d.*
MONOGRAPH III. On the CROCODILIAN REMAINS found in the ELGIN SANDSTONES. By T. H. HUXLEY. 14*s.* 6*d.*
MONOGRAPH IV. On the CHIMÆROID FISHES of the British Cretaceous Rocks. By E. T. NEWTON. 5*s.*
The VERTEBRATA of the FOREST BED SERIES of NORFOLK and SUFFOLK. By E. T. NEWTON. 7*s.* 6*d.*
CATALOGUE of SPECIMENS in the Museum of Practical Geology, illustrative of British Pottery and Porcelain. By Sir H. DE LA BECHE and TRENHAM REEKS. 155 Woodcuts. 2nd Ed. by T. REEKS and F. W. RUDLER. 1*s.* 6*d.*; 2*s.* in boards.
A DESCRIPTIVE GUIDE to the MUSEUM of PRACTICAL GEOLOGY, with Notices of the Geological Survey, the School of Mines, and the Mining Record Office. By ROBERT HUNT and F. W. RUDLER. 6*d.* (3rd Ed.)
A DESCRIPTIVE CATALOGUE of the ROCK SPECIMENS in the MUSEUM of PRACTICAL GEOLOGY. By A. C. RAMSAY, H. W. BRISTOW, H. BAUERMAN, and A. GEIKIE. 1*s.* (3rd Edit.) (*Out of print.*) 4th Ed. in progress.
CATALOGUE of the FOSSILS in the MUSEUM of PRACTICAL GEOLOGY:
CAMBRIAN and SILURIAN, 2*s.* 6*d.*; CRETACEOUS, 2*s.* 9*d.*; TERTIARY and POST-TERTIARY 1*s.* 8*d.*

SHEET MEMOIRS OF THE GEOLOGICAL SURVEY.

Those marked (O.P.) are Out of Print.

4 - - FOLKESTONE and RYE. By F. DREW. 1*s.*
7 - - PARTS of MIDDLESEX, &c. By W. WHITAKER. 2*s.* (O.P.)
10 - - TERTIARY FLUVIO-MARINE FORMATION of the ISLE of WIGHT. By EDWARD FORBES.
10 - - The ISLE OF WIGHT. By H. W. BRISTOW. 6*s.* (O.P.)
12 - - S. BERKSHIRE and N. HAMPSHIRE. By H. W. BRISTOW and W. WHITAKER. 3*s.* (O.P.)
13 - - PARTS of OXFORDSHIRE and BERKSHIRE. By E. HULL and W. WHITAKER. 3*s.* (O.P.)
34 - - PARTS of WILTS. and GLOUCESTERSHIRE. By A. C. RAMSAY, W. T. AVELINE, and E. HULL. 8*d.*
44 - - CHELTENHAM. By E. HULL. 2*s.* 6*d.*
45 - - BANBURY, WOODSTOCK, and BUCKINGHAM. By A. H. GREEN. 2*s.*
45 SW - - WOODSTOCK. By E. HULL. 1*s.*
47 - - N.W. ESSEX & N.E. HERTS. By W. WHITAKER, W. H. PENNING, W. H. DALTON, & F. J. BENNETT. 3*s.* 6*d.*
48 SW - - COLCHESTER. By W. H. DALTON. 1*s.* 6*d.*
48 SE - - EASTERN END of ESSEX (WALTON NAZE and HARWICH). By W. WHITAKER. 9*d.*
48 NW, NE. IPSWICH, HADLEIGH, and FELIXSTOW. By W. WHITAKER, W. H. DALTON, and F. J. BENNETT. 2*s.*
49 S, 50 SE - ALDBOROUGH, &c. By W. H. DALTON. Edited, with additions, by W. WHITAKER. 1*s.*
50 SW - - STOWMARKET. By W. WHITAKER, F. J. BENNETT, and J. H. BLAKE. 1*s.*
50 NW - - DISS, EYE, &c. By F. J. BENNETT. 2*s.*
51 SW - - CAMBRIDGE. By W. H. PENNING and A. J. JUKES-BROWNE. 4*s.* 6*d.*
51 SE - - BURY ST. EDMUNDS and NEWMARKET. By F. J. BENNETT, J. H. BLAKE, and W. WHITAKER. 1*s.*
53 SE - - PART of NORTHAMPTONSHIRE. By W. T. AVELINE and RICHARD TRENCH. 8*d.*
53 NE - - PARTS of NORTHAMPTONSHIRE and WARWICKSHIRE. By W. T. AVELINE. 8*d.* (O.P.)
63 SE - - PART of LEICESTERSHIRE. By W. TALBOT AVELINE, and H. H. HOWELL. 8*d.* (O.P.)
64 - - - RUTLAND, &c. By J. W. JUDD. 12*s.* 6*d.*
66 NE, SE - NORWICH. By H. B. WOODWARD. 7*s.*
66 SW - - ATTLEBOROUGH. By F. J. BENNETT. 1*s.* 6*d.*
68 E - - CROMER. By C. REID. 6*s.*
68 NW, SW. FAKENHAM, WELLS, &c. By H. B. WOODWARD. 2*s.*
70 - - SW LINCOLNSHIRE, &c. By A. J. JUKES-BROWNE and W. H. DALTON. 4*s.*
71 NE - - NOTTINGHAM. By W. T. AVELINE. (2nd Ed.) 1*s.*
79 NW - - RHYL, ABERGELE, and COLWYN. By A. STRAHAN. (Notes by R. H. TIDDEMAN.) 1*s.* 6*d.*
80 NW - - PRESCOT, LANCASHIRE. By E. HULL. (3rd Ed. With additions by A. STRAHAN.) 3*s.*
80 NE - - ALTRINCHAM, CHESHIRE. By E. HULL. 8*d.* (O.P.)
80 SW - - CHESTER. By A. STRAHAN. 2*s.*
81 NW, SW. STOCKPORT, MACCLESFIELD, CONGLETON, & LEEK. By E. HULL and A. H. GREEN. 4*s.*
82 SE - - PARTS of NOTTINGHAMSHIRE and DERBYSHIRE. By W. T. AVELINE. (2nd Ed.) 6*d.*
82 NE - - PARTS of NOTTINGHAMSHIRE, YORKSHIRE, and DERBYSHIRE. By W. T. AVELINE. 8*d.*
84 - - EAST LINCOLNSHIRE. By A. J. JUKES-BROWNE.
87 NW - - PARTS of NOTTS, YORKSHIRE, and DERBYSHIRE. (2nd Ed.) By W. T. AVELINE. 6*d.*
87 SW - - BARNSLEY. By A. H. GREEN. 9*d.*
88 SW - - OLDHAM. By E. HULL. 2*s.*
88 SE - - PART of the YORKSHIRE COAL-FIELD. By A. H. GREEN, J. R. DAKYNS, and J. C. WARD. 1*s.*
88 NE - - DEWSBURY, HUDDERSFIELD, and HALIFAX. By A. H. GREEN, J. R. DAKYNS, J. C. WARD, and R. RUSSELL. 6*d.*
89 SE - - BOLTON, LANCASHIRE. By E. HULL. 2*s.*
89 SW - - WIGAN. By EDWARD HULL (2nd Ed.) 1*s.* (O.P.)
90 SE - - The COUNTRY between LIVERPOOL and SOUTHPORT. By C. E. DE RANCE. 3*d.* (O.P.)
90 NE - - SOUTHPORT, LYTHAM, and SOUTH SHORE. By C. E. DE RANCE. 6*d.*
91 SW - - The COUNTRY between BLACKPOOL and FLEETWOOD. By C. E. DE RANCE. 6*d.*
91 NW - - SOUTHERN PART of the FURNESS DISTRICT in N. LANCASHIRE. By W. T. AVELINE. 6*d.*
92 SE - - BRADFORD and SKIPTON. By J. R. DAKYNS, C. FOX-STRANGWAYS, R. RUSSELL, and W. H. DALTON. 6*d.*
93 NW - - NORTH and EAST of HARROGATE. By C. FOX-STRANGWAYS. 6*d.*
93 NE - - The COUNTRY between YORK and MALTON. By C. FOX-STRANGWAYS. 1*s.* 6*d.*
93 W - - CARBONIFEROUS ROCKS N. and E. of LEEDS, and the PERMIAN and TRIASSIC ROCKS about TADCASTER. By W. T. AVELINE, A. H. GREEN, J. R. DAKYNS, J. C. WARD and R. RUSSELL. 6*d.* (O.P.)

Digitized by Google

93 SE, 94 W COUNTRY between YORK & HULL. By J. R. Dakyns, C. Fox-Strangways, and A. G.
94 NW - - DRIFFIELD. By J. R. Dakyns and C. Fox-Strangways. 9*d.*
94 NE - - BRIDLINGTON BAY. By J. R. Dakyns and C. Fox-Strangways. 1*s.*
95 SW, SE - SCARBOROUGH and FLAMBOROUGH HEAD. By C. Fox-Strangways. 1*s.*
95 NW - WHITBY and SCARBOROUGH. By C. Fox-Strangways and G. Barrow. 1*s.* 6*d.*
96 SE - NEW MALTON, PICKERING, and HELMSLEY. By C. Fox-Strangways. 1*s.*
96 NE - - ESKDALE, ROSEDALE, &c. By C. Fox-Strangways, C. Reid and G. Barrow. 1*s.* 6*d.*
96 NW, SW NORTHALLERTON and THIRSK. By C. Fox-Strangways, A. G. Cameron, and G. Barrow. 1*s.* 6*d.*
98 SE - - KIRKBY LONSDALE and KENDAL. By W. T. Aveline, T. Mc K. Hughes, and R. H. Tiddeman. 2*s.*
98 NE - - KENDAL, WINDERMERE, SEDBERGH, & TEBAY. By W. T. Aveline & T. Mc K. Hughes. 6*d.* (O.P.)
101 SE - NORTHERN PART of the ENGLISH LAKE DISTRICT. By J. C. Ward. 9*s.*
104 SW, SE NORTH CLEVELAND. By G. Barrow.
108 SE - OTTERBURN and ELSDON. By Hugh Miller. (Notes by C. T. Clough.)

THE MINERAL DISTRICTS OF ENGLAND AND WALES ARE ILLUSTRATED BY THE FOLLOWING PUBLISHED MAPS OF THE GEOLOGICAL SURVEY.

COAL-FIELDS OF ENGLAND AND WALES.

Scale, one inch to a mile.

Anglesey, 78 (SW).
Bristol and Somerset, 19, 35.
Coalbrook Dale, 61 (NE & SE).
Clee Hill, 53 (NE, NW).
Flintshire and Denbighshire, 74 (NE & SE), 79 (NE, SE).
Derby and Yorkshire, 71 (NW, NE & SE), 82 (NW & SW), 81 (NE), 87 (NE, SE), 88 (SE).
Forest of Dean, 43 (SE & SW).
Forest of Wyre, 61 (SE), 55 (NE).
Lancashire, 80 (NW), 81 (NW), 89, 88 (SW, NW).
Leicestershire, 71 (SW), 63 (NW).
Northumberland & Durham, 103, 105, 106 (SE), 109 (SW, SE).
N. Staffordshire, 72 (NW), 72 (SW), 73 (NE), 80 (SE), 81 (SW).
S. Staffordshire, 54 (NW), 62 (SW).
Shrewsbury, 60 (NE), 61 (NW & SW).
South Wales, 36, 37, 38, 40, 41, 42 (SE, SW).
Warwickshire, 62 (NE SE), 63 (NW SW), 54 (NE), 53 (NW).
Yorkshire, 88 (NE, SE), 87 (SW), 92 (SE), 93 (SW).

GEOLOGICAL MAPS.

Scale, six inches to a mile.

The Coal-fields and other mineral districts of the N. of England are published on a scale of six inches to a mile, at 4*s.* to 6*s.* each. MS. Coloured Copies of other six-inch maps, not intended for publication, are deposited for reference in the Geological Survey Office, 28, Jermyn Street, London.

Lancashire.

Sheet.	Sheet.	Sheet.
15. Ireleth.	73. Todmorden.	97. Oldham.
16. Ulverstone.	77. Chorley.	100. Knowsley.
17. Cartmel.	78. Bolton-le-Moors.	101. Billinge.
22. Aldingham.	79. Entwistle.	102. Leigh, Lowton.
47. Clitheroe.	80. Tottington.	103. Ashley, Eccles.
48. Colne.	81. Wardle.	104. Manchester, Salford.
49. Laneshaw Br.	84. Ormskirk.	
55. Whalley.	85. Standish.	105. Ashton-under-Lyne.
56. Haggate.	86. Adlington.	
57. Winewall.	87. Bolton-le-Moors.	106. Liverpool.
61. Preston.	88. Bury, Heywood.	107. Prescott,
62. Balderstone.	89. Rochdale, &c.	108. St. Helen's.
63. Accrington.	92. Bickerstaffe.	109. Winwick.
64. Burnley.	93. Wigan.	111. Cheedale.
65. Stiperden Moor.	94. West Houghton.	112. Stockport.
69. Layland.	95. Radcliffe.	113. Part of Liverpool.
70. Blackburn.	96. Middleton, Prestwich.	
71. Haslingden.		
72. Cliviger, Bacup.		

Durham.

1. Ryton.	6. Winlaton.	11. Ebchester.
2. Gateshead.	7. Washington.	12. Tantoby.
3. Jarrow.	8. Sunderland.	13. Chester-le-St.
4. S. Shields.	9. ———	16. Hunstanworth.
5. Greenside.	10. Edmondbyers.	17. Waskerley.

Durham—*continued.*

Sheet.	Sheet.	Sheet.
18. Muggleswick.	25. Wolsingham.	38. Maize Beck.
19. Lanchester.	26. Brancepeth.	41. Cockfield.
20. Hetton-le-Hole.	30. Benny Seat.	42. Bp. Auckland.
22. Wear Head.	32. White Kirkley.	46. HawksleyHillHo.
23. Eastgate.	33. Hamsterley.	52. Barnard Castle.
24. Stanhope.	34. Whitworth.	53. Winston.

Northumberland.

44. Rothbury.	80. Cramlington.	98. Walker.
45. Longframlington.	81. Earsdon.	101. Whitfield.
	82. NE. of Gilsland.	102. Allendale Town.
46. Broomhill.	83. Coadley Gate.	
47. Coquet Island.	87. Heddon.	103. Slaley.
54. Longhorsley.	88. Long Benton.	105. Newlands.
55. Ulgham.	89. Tynemouth.	106. Blackpool Br.
56. Druridge Bay.	91. Greenhead.	107. Allendale.
63. Netherwitton.	92. Haltwhistle.	108. Blanchland.
64. Morpeth.	93. HaydonBridge.	109. Shotleyfield.
65. Newbiggin.	94. Hexham.	110. Wellhope.
72. Bedlington.	95. Corbridge.	111. Allenheads.
73. Blyth.	96. Horsley.	112.
	97. Newcastle.	

Cumberland.

55. Searness.	65. Dockraye.	74. Wastwater
56. Skiddaw.	69. Buttermere	75. Stonethwaite Fell.
63. Thackthwaite.	70. Grange.	
64. Keswick.	71. Helvellyn.	

Westmorland.

2. Tees Head.	12. Patterdale.	25. Grasmere.
6. Dufton Fell.	18. Near Grasmere.	38. Kendal.

Yorkshire.

7. Redcar.	116. Conistone Moor.	260. Honley.
9. ———	133. Kirkby Malham.	261. Kirkburton.
12. Bowes.		262. Darton.
13. Wycliffe.	184. Dale End.	263. Hemsworth.
20. Lythe.	185. Kildwick.	264. Campsall.
24. Kirkby Ravensworth.	200. Keighley.	272. Holmfirth.
	201. Bingley.	273. Penistone.
25. Aldborough.	202. Calverley.	274. Barnsley.
32. Whitby.	203. Seacroft.	275. Darfield.
33. ———	204. Aberford.	276. Brodsworth.
38. Marske.	215. Peeke Well.	281. Langsell.
39. Richmond.	216. Bradford.	282. Wortley.
46. ———	217. Calverley.	283. Wath upon Dearne.
47. Robin Hood's Bay.	218. Leeds.	284. Conisborough.
	219. Kippax.	287. Low Bradford.
53. Downholme.	231. Halifax.	288. Ecclesfield.
68. Leybourne.	232. Birstal.	289. Rotherham.
82. Kidstones.	233. East Ardsley.	290. Braithwell.
84. E. Witton.	234. Castleford.	293. Hallam Moors.
97. Foxup.	246. Huddersfield.	295. Handsworth.
98. Kirk Gill.	247. Dewsbury.	296. Laughton-en-le-Morthen.
99. Haden Carr.	248. Wakefield.	
100. Lofthouse.	249. Pontefract.	299. ———
115. Arncliffe.	250. Darrington.	300. Harthill.

MINERAL STATISTICS.

Embracing the produce of Coals, Metallic Ores, and other Minerals. By R. Hunt. From 1853 to 1857, inclusive, 1*s.* 6*d.* each. 1858, *Part I.*, 1*s.* 6*d.*; *Part II.*, 5*s.* 1859, 1*s.* 6*d.* 1860, 3*s.* 6*d.* 1861, 2*s.*; and Appendix, 1*s.* 1862, 2*s* 6*d.* 1863. 2*s.* 6*d.* 1864, 2*s.* 1865, 2*s.* 6*d.* 1866 to 1881, 2*s.* each.
(These Statistics are now published by the *Home Office*, as parts of the *Reports of the Inspectors of Mines.*)

THE IRON ORES OF GREAT BRITAIN.

Part I. The North and North Midland Counties of England (*Out of print*). Part II. South Staffordshire. Price 1*s.* Part III. South Wales. Price 1*s.* 3*d.* Part IV. The Shropshire Coal-field and North Staffordshire. 1*s.* 3*d.*

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

554.2 O700 c.1
geology of the country around Otterb
086 739 166
UNIVERSITY OF CHICAGO

Digitized by Google